32392
QR 36-10

POWER SUPPLIES UNLIMITED

NJE CORPORATION

KENILWORTH, NEW JERSEY

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INSTRUCTION MANUAL

QR LINE
SERIES REGULATED - MAGNETIC AMPLIFIER
POWER SUPPLIES

SERIAL NUMBER ~~@~~ X388-5

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801344
Rev A
1/7/64

WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES WHICH ARE DANGEROUS AND CAN BE FATAL IF CONTACTED BY OPERATING PERSONNEL. EXTREME CAUTION MUST BE EXERCISED WHEN WORKING WITH THIS EQUIPMENT.

INTRODUCTION

DEVIATIONS:

This manual covers the Standard NJE Power Supplies as indicated in Section I herein. Where deviations to the specifications are built into equipment at the customer's request, the nature of the deviation as it affects this manual is indicated in a Specification Sheet which precedes Section I. If special Schematic Diagrams, Parts Placement Drawings and/or Spare Parts List(s) are required for the deviation, they will be found in Section V of the manual, in place of, or along with the Standard material.

CORRESPONDENCE:

All correspondence must reference the complete description of the unit as shown on the identification label located at the rear of the power supply.

In requesting Spare Parts or information relative to parts, the Reference Designation, the rating, the description, and the NJE Part Number must be specified for each part in question.

DESIGN IMPROVEMENTS:

NJE Corporation reserves the right to make design improvements on any instrument without prior notice.

REPRODUCTION:

No written material, drawings, text figures, or any part of this Instruction Manual may be reproduced without express written consent of NJE Corporation.

801595
Rev. A.: 6/19/67

REPAIR SERVICE

NJE Corporation provides complete repair facilities at the main plant and at local service centers as listed in the rear of the manual. These repair facilities are adequately staffed with factory trained technicians to assure our customers of the most knowledgeable and expedient servicing of our equipment. All equipment forwarded to these facilities must be adequately packaged to prevent damage in transit.

OUT OF WARRANTY SERVICE:

Forward defective equipment to factory or local service center prepaid. A full description of difficulties encountered or the repair required should accompany this shipment. An estimate of the cost of repair will be submitted to you. The necessary servicing will be performed only upon receipt of your written service orders. Your equipment will be returned to you via collect shipment unless otherwise specified on your service order.

IN WARRANTY SERVICE:

If, during the warranty period the power supply indicates an inherent defect, immediately communicate with your nearest NJE Field Representative in your area. If, after examination, he concurs that the unit is defective under the warranty conditions, he will provide written authorization for the return of the unit to the factory or the local field service center, whichever is nearer. NJE Corporation will not assume any transportation charges on incoming equipment without the concurring written approval from its field representative.

801596
Rev. A.: 6/19/67

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SECTION I

SPECIFICATIONS

1.1 GENERAL: The QR line of Magnetic Amplifier, Series Regulator Power Supplies is designed for use in applications requiring a well regulated and stable source of DC power at high values of current. The specifications herein are tabulated where ratings change from unit to unit (See Table I-1) and are generalized into paragraphs where ratings are common.

1.2 GENERAL ELECTRICAL SPECIFICATIONS:

1.2.1 Input: 105 to 125 volts, 55 to 65 cps, single phase. Input currents are specified in Table 1-1.

1.2.2 Output Voltage and Current: See Table 1-1.

1.2.3 Static Regulation:

1.2.3.1 Load: At constant input voltage, the regulation is less than the figure indicated in Table 1-1 for a load change from half load to full load and is less than the figure indicated in Table 1-1 for a load change from half load to no load.

1.2.3.2 Line: At constant load, the regulation is less than 0.02% or 0.5 millivolts, whichever is greater, for a line change from 115 to 105 volts and less than 0.02% or 0.5 millivolts, whichever is greater, for a line change from 115 to 125 volts.

1.2.4 Ripple: 3 millivolts, peak to peak, maximum.

1.2.5 Transient Response: For a ±10% prolonged step change in line voltage, the output voltage will remain in the regulated region. For a no load to full load or a full load to no load prolonged step change, the output voltage will return to within 50 millivolts of the regulated region in less than 50 microseconds.

1.2.6 Meters: Voltmeter and ammeter rated accurate to 2% of full scale value are provided on the front panel.

1.2.7 Polarity: The output may be "floated" up to 500V peak above ground. Either polarity may be grounded to chassis by means of terminals provided.

1.2.8 Duty: Continuous at ambient temperatures from 0° C to 45° C. Operation above 45° C is allowed provided the output current is derated linearly to zero at 80° C.

1.2.9 Remote Sensing: Sensing terminals, separate from the Output terminals, provide sensing and load regulation against the voltage at the load rather than the voltage at the power supply output terminals. This eliminates the otherwise unavoidable load regulation due to the voltage drop in the wires connecting the supply to the load. This feature does not eliminate voltage excursions resulting from load transients through load line impedance.

1.2.10 Remote Programming: The output voltage may be controlled accurately from a remote point if desired, by varying the resistance across the REMOTE PROGRAM terminals. The sensitivity of this circuit is approximately 140 ohms per volt above the minimum voltage within the voltage limits of Table 1-1.

1.2.11 Dualling: Two or more units may be operated in series to provide higher voltage output at rated current. Two like units may be operated in parallel provided that the total current drawn is derated by 10%. All dual unit installations must meet the cooling requirements of paragraph 1.3.2. The effectiveness of 3 or more units in parallel can be determined only by a test of the system.

1.2.12 Termination: A barrier type terminal strip at the rear of the unit provides interface connection for input, output, remote sensing, remote programming and ground.

1.2.13 Protection: Variable electronic current limiting by front panel control adjusts maximum current over range of 5% to 105% of supply rating. Short circuit proof design is 100% factory tested. Protective fuse will interrupt input power in the event of internal failure.

1.2.14 Output Capacitor: The output capacitor is brought out to separate terminals at the rear of the unit. For normal operation, the factory set jumpers from the output capacitor to the respective output terminals should be left in place. Where improved transient response and dynamic characteristics are desired, the jumpers may be removed and an output capacitance connected directly at the remote load.

1.2.15 CONSTANT CURRENT: The current limiting feature makes the power supply essentially a constant current device. In this mode of operation the current regulation is better than 5% over the full voltage range of the supply. Improved current regulation can be achieved by sensing across an appropriate external resistor in series with the load. No internal modifications are required.

1.2.16 Resolution: Continuously variable ten turn Output Adjust potentiometer provides the resolution indicated in Table 1-1.

1.3 MECHANICAL SPECIFICATIONS:

1.3.1 Outline Drawing: Table 1-1 indicates which Outline Drawing is applicable to the unit in question.

1.3.2 Airflow: Units of panel height less than 5-1/4" do not have blowers and depend on conduction and convection for cooling. Units of panel height 5-1/4" and greater have internal blowers and depend on forced air cooling in addition to the conduction and convection cooling. Air flow paths as indicated in the appropriate Outline drawing must not be blocked. Where two or more units are rack-mounted one above the other or where adjacent equipment increases the ambient temperature above the limits specified in paragraph 1.2.8 above, filler panels of at least 1-3/4" height should be installed above and below the power supplies in question.

1.3.3 Mounting: When installed in racks, it is recommended that support angles be provided so that the power supply weight is not supported entirely by the front panel mounting hardware.

1.3.4 Finish: Front Panel finished in dark grey enamel equivalent to FED STD 595 chip #26132. Panel marking is white. All other finishes are appropriate paint, plating or chemical film as required.

1.4 CPTIONAL FEATURES:

Table 1-2 indicates the specific optional features which are available on any given unit. The general description of these optional features follows:

1.4.1 Suffix(-50): Extension of the Input frequency range to 47-65 cps. This option requires that the Cutput current be derated by 1/6 of the maximum rating as specified in Table 1-1.

1.4.2 Suffix (-B): Addition of bench adapter.

1.4.3 Suffix (-P): Addition of three wire power cord and plug.

1.4.4 Suffix (-SF): Non-standard finish to front panel of unit.
1.4.4.1 Where specifying (-SF) option customer must provide NJE the following information:

Color to be used (preferrably FED-STD 595 chip number).

Color to be used for marking.

Process to be used if other than NJE Standard finish process.

Whether paint is to be supplied by customer or NJE.

1.4.5 Suffix (-LV) and/or (-LC): Output Adjust (-LV) or Current Control (-LC) potentiometer and knob replaced by a single turn screwdriver adjust potentiometer with shaftlock. (-LV) option changes Cutput Adjust resolution to 1%.

NCTE: Ten-turn controls with decade dials have built-in locks.

1.4.6 Prefix (E): Deletion of meters and replacement of ten-turn Output adjust potentiometer by Coarse and Fine single turn potentiometers on concentric shaft This reduces resolution to 0.05%.

NCTE: Buildup of final model number for a QR-36-10 without meters and with line cord and bench adapter is as follows: EQR-36-10-B-P.

NCTE: NJE Corporation invites requests for quotations on special requirements which can be accomplished by deviations of standard catalogue units.

MODEL NO.	OUTPUT		LOAD[1] REGULATION	INPUT AMPS	WEIGHT		OUTLINE DWG.	RESO-LUTION
	VOLTS	AMPS			NET	SHIP		
QR-10-10	0 -10	0-10	0.005% OR 0.5MV	5.0	40	75	303285 303291	2MV
QR-15-20	0 -15	0-20	0.01 % OR 1 MV	10.0	70	105	303317 303316	3MV
QR-18-6	0 -18	0-6	0.005% OR 0.5MV	5.0	40	75	303285 303291	3MV
QR-36-4	0 -36	0-4	0.005% OR 0.5MV	5.0	40	75	303285 303291	5MV
QR-36-10	0 -36	0-10	0.01 % OR 0.5MV	11.0	75	105	303317 303316	5MV
QR-60-2.5	0 -60	0-2.5	0.005% OR 0.5MV	5.0	40	75	303285 303291	7MV
QR-60-6	0 -60	0-6	0.005% OR 0.5MV	10.0	75	105	303317 303316	7MV
QR-160-1.2	0 -160[2]	0-1.2	0.005% OR 0.5MV	6.0	40	75	303285 303291	16MV
QRP-160-3	60-160	0-3	0.005% OR 0.5MV	10.0	75	105	303317 303316	11MV

(1) WHICHEVER IS GREATER.
(2) PRELOAD OF 0.3A REQUIRED BELOW 50V.

TABLE 1-1

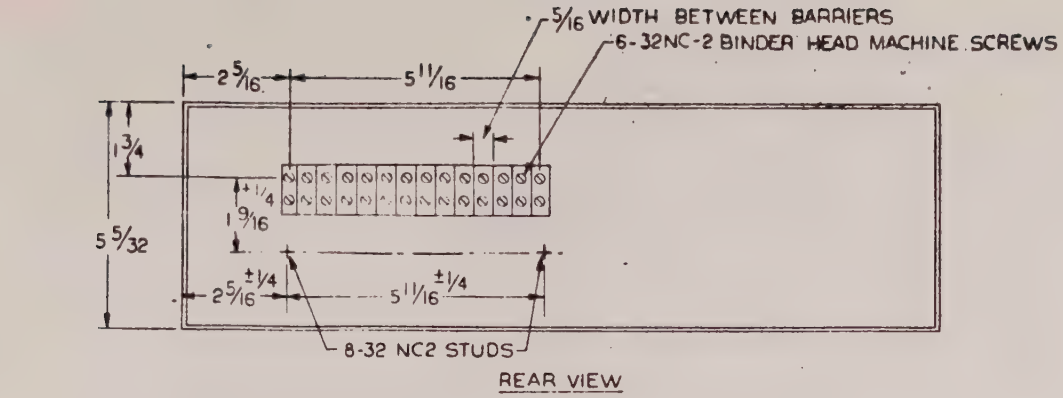
TABULATED SPECIFICATIONS

MODEL NO.	OPTION						
	(-50)	(-B)	(-P)	(-SF)	(-LV)	(-LC)	(E)
QR-10-10	X	X	X	X	X	X	X
QR-15-20	X	X	X	X	X	X	X
QR-18-6	X	X	X	X	X	X	X
QR-36-4	X	X	X	X	X	X	X
QR-36-10	X	X	X	X	X	X	X
QR-60-2.5	X	X	X	X	X	X	X
QR-60-6	X	X	X	X	X	X	X
QR-160-1.2	X	X	X	X	X	X	X
QRP-160-3	X	X	X	X	X	X	X

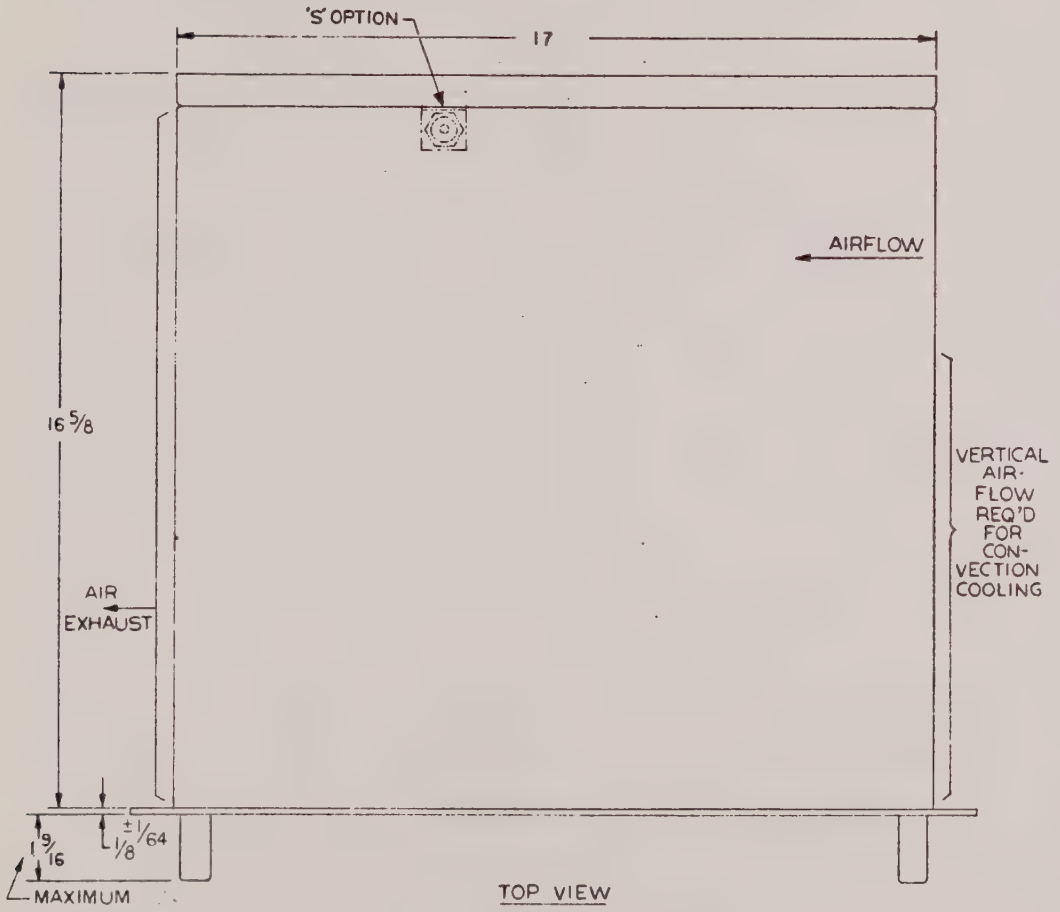
X MEANS OPTION AVAILABLE

TABLE 1-2

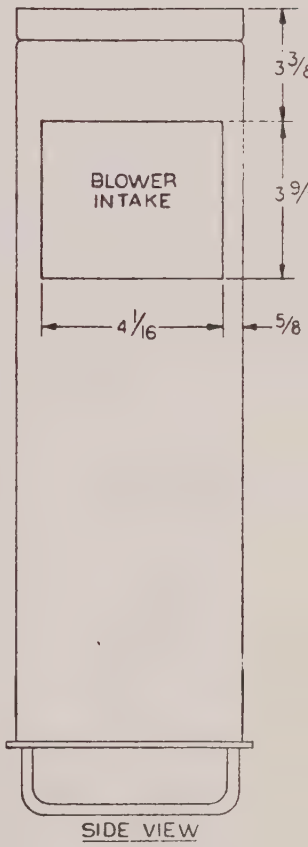
OPTION LIST



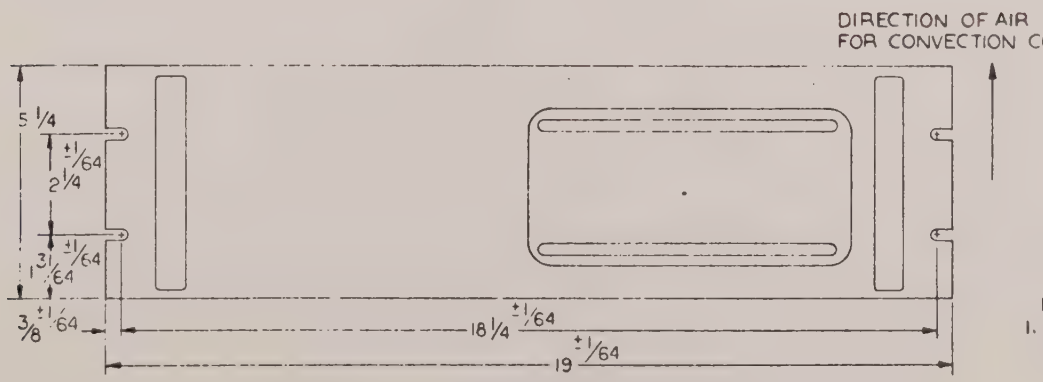
REAR VIEW



TOP VIEW

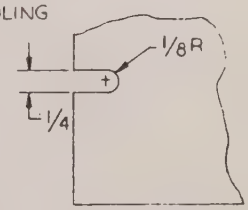


SIDE VIEW



FRONT VIEW

DIRECTION OF AIR FLOW FOR CONVECTION COOLING

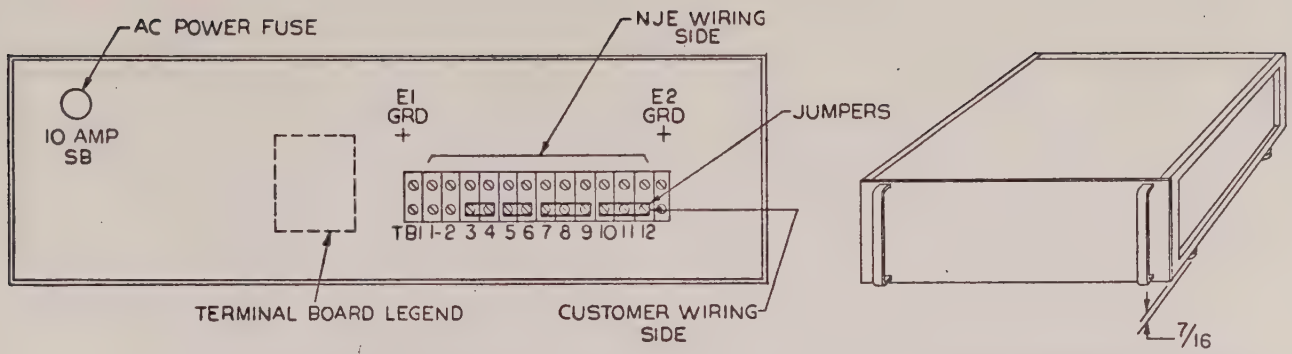


TYPICAL NOTCH

NOTE:
1. ALL TOLERANCES ± 1/32 UNLE
OTHERWISE SPECIFIED.

OUTLINE DRAWING
5 1/4" PANEL SERIES

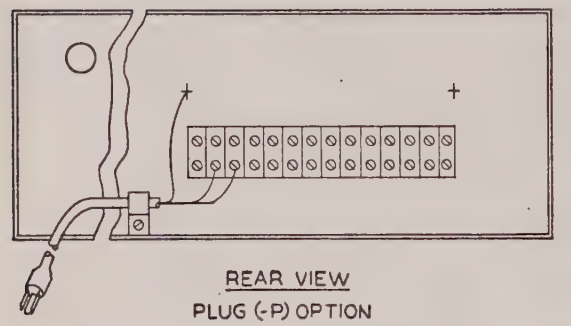
303317



REAR VIEW

REAR PLATE ELEMENTS

BENCH ADAPTER (-B) OPTION



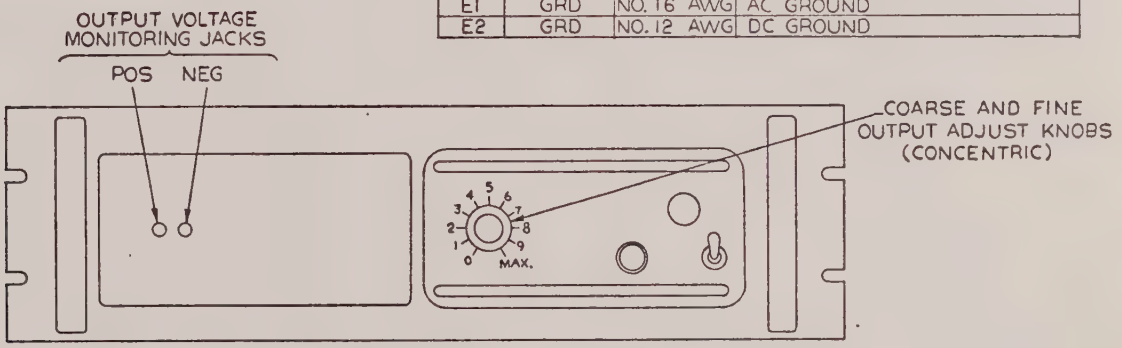
REAR VIEW

PLUG (-P) OPTION

TB1 TERMINAL BOARD LEGEND				
TERM NO.	SCREENED FUNCTION	RECOM'D WIRE SIZE	REMARKS	
1	AC	NO. 16 AWG	HIGH SIDE OF AC INPUT	
2	AC	NO. 16 AWG	RETURN SIDE OF AC INPUT	
3	REMOTE PROGRAM	NO. 20 AWG SHIELD. PR.	NORMALLY JUMPED TOGETHER	
4				
5	DUALLING	NO. 20 AWG SHIELDED	NORMALLY JUMPED TOGETHER	2
6				
7	POS SEN	NO. 20 AWG	NORMALLY JUMPED TO POS OUT	1
8	POS OUT	NO. 12 AWG		
9	POS CAP	NO. 12 AWG	NORMALLY JUMPED TO POS OUT	
10	NEG CAP	NO. 12 AWG	NORMALLY JUMPED TO NEG OUT	
11	NEG OUT	NO. 12 AWG		
12	NEG SEN	NO. 20 AWG	NORMALLY JUMPED TO NEG OUT	1

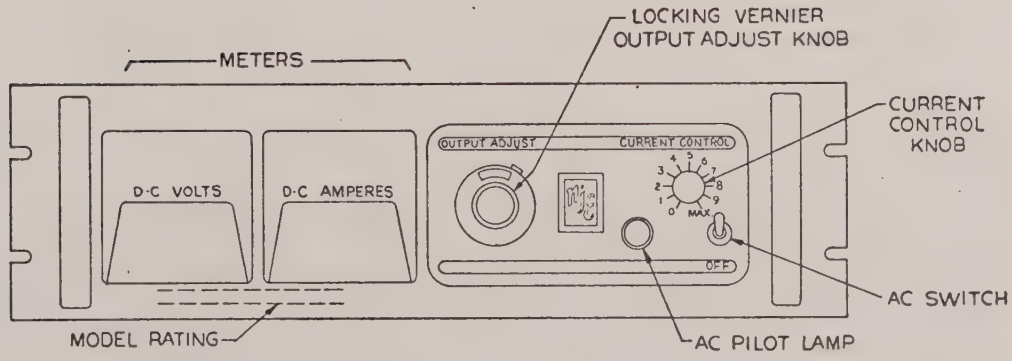
1 - TWISTED PAIR WHERE USED
2 TERM. NO. 5 IS DUALLING DRIVE POINT

E1	GRD	NO. 16 AWG	AC GROUND
E2	GRD	NO. 12 AWG	DC GROUND



FRONT VIEW

NON - METERED FRONT PANEL ELEMENTS
OPTION (E-)



FRONT VIEW

FRONT PANEL ELEMENTS
QR LINE
5 1/4" PANEL SERIES

SECTION II

INSTALLATION AND OPERATION

2.1 UNPACKING: The power supply is shipped in a corrugated carton which is floated on sufficient insulation in a heavy-duty shipping carton. Aside from normal precaution against damage to the unit in opening the cartons and removing the unit, no special procedures are required. The carton should be opened immediately upon receipt and the contents inspected for shipping damage. The power supply was checked electrically and mechanically before it left the factory, and is warranted to be in perfect operating condition. This warranty does not cover possible damage incurred during shipment. Therefore, any evidence of mishandling, such as broken, deformed or missing parts, should be brought to the attention of the transportation company, and a claim should be entered. Remove top cover plate and inspect all components and wiring, both on the chassis panel, as well as the mechanical condition of the housing. The literature packed with the supply should be removed and held for reference in operating the equipment.

2.2 INSTALLATION: Refer to Table 1-1 which indicates which Outline Drawing is to be followed for the model in question. This Outline Drawing shows mounting dimensions, air flow requirements, interface wiring information and other data pertinent to proper installation. Careful observance of all the specification requirements in Section I is essential to a proper installation. READ THE SPECIFICATIONS CAREFULLY BEFORE PROCEEDING.

When the unit has been properly placed in position or mounted in its rack and secured in place by the panel screws, electrical connections should be made in accordance with the following step-by-step procedure. Wire sizes to be used and the terminal locations are specified on the appropriate Outline Drawing of Section 1-3. Terminal functions listed in the following instructions are clearly screened on the equipment itself, as well as being indicated on both the outline of Section 1-3 and the Schematic Diagram of Section V.

2.3 STANDARD SINGLE UNIT ELECTRICAL INSTALLATION:

2.3.1 Output Grounding: Connect either the positive (POS OUT) or negative (NEG OUT) DC output terminal of the supply (depending upon desired output polarity) directly to the chassis ground terminal (GRD) at the barrier strip on the rear of the chassis, and connect the ground terminal to the system ground.

NOTE: If it is necessary that the power supply circuit float above or below ground, it is recommended that the output terminal should be connected to the chassis ground terminal by a 0.1 microfarad 600 VDC capacitor in place of the direct connection. Use of this by-pass capacitor will improve the stability of the circuit in the ungrounded condition, and reduce the effect of external interference and hum. Refer to Polarity Specification in Section I for maximum limitation on floating voltage permitted.

2.3.2 Output Connection: Connect the positive and negative output terminals (POS OUT) and (NEG OUT), respectively to the corresponding terminals of the external load. Use heavier gauge wire than that specified if long distances to the load are involved.

2.3.3 Remote Sensing: All units are shipped from the factory with the REMOTE SENSING feature jumpered out on the inter-connection terminal board as follows: (POS SENS) connected to (POS OUT) and (NEG SENS) connected to (NEG OUT). With this connection, the regulation specifications are met ONLY at the output terminals of the supply. If it is desired to have accurate regulation at the remote load point, rather than at the output terminals, proceed as follows:

Connect the output terminals to the load per Paragraph 2.3.2 above. Remove the Jumpers from (POS SENS) to (POS OUT) and (NEG SENS) to (NEG OUT) respectively. Observing correct polarity, run a twisted pair of No. 20 AWG wire (or larger) from (POS SENS) to the positive load point and from (NEG SENS) to the negative load point.

WARNING: DO NOT OPERATE POWER SUPPLY WITHOUT THE SENSING LEADS CONNECTED EITHER REMOTELY OR LOCALLY. MOST CUSTOMER COMPLAINTS OF POOR OPERATION ARE DUE TO IMPROPER SENSING LEAD CONNECTION.

WHEN THE POINT OF REMOTE SENSING IS MORE THAN 10 FEET FROM THE POWER SUPPLY, OSCILLATIONS MAY DEVELOP. A POSSIBLE CURE IS TO CONNECT REMOTE CAPACITANCE AS DESCRIBED IN PARAGRAPH 2.3.4 AND AS CLOSE TO THE POINT OF SENSING AS IS PHYSICALLY POSSIBLE.

2.3.4 Output Capacitor Connections: This feature is not provided on all units. When included in the equipment, the terminals are listed as (POS CAP) and (NEG CAP) on the Outline Drawing. The power supply has been shipped from the factory with the appropriate filter capacitors connected to the appropriate output terminals at the interconnection terminal board. This arrangement is satisfactory for most applications. However, if better transient and dynamic characteristics are required, further improvement can be effected by using an independent capacitor mounted as close to the ultimate load as is practical.

The capacitor used should have the same voltage rating of the power supply output capacitance (see the Schematic Diagram for the rating of the capacitor connected to the Pos Cap and Neg Cap terminals) and at least the same capacitance rating should be used. Additional capacitors may be ordered by specifying the NJE Part Number of the output capacitor from the Spare Parts List of Section V.

Reconnections are made as follows: Remove the jumper connection provided between (Pos Out) and (Pos Cap) and between (Neg Out) and (Neg Cap). The load leads should be connected as in Paragraph 2.3.2 above. Connect the new capacitor directly at the load being careful to observe polarity. In order to make this connection effective, it will be necessary to utilize the Remote Sensing Connections described in Paragraph 2.3.3 above.

2.3.5 Remote Programming:

To utilize either the Remote Voltage Program or Remote Current Program when specified per Section I, remove jumper across the appropriate terminals and connect a resistor across the Remote Program terminals. If the resistor is to be located remotely from the power supply, a twisted pair of No. 20 AWG should be used. The resistance (R) of the remote program resistor may be calculated as follows:

2.3.5.1 Remote Voltage Program

$R \ (\Omega/V) \ (V_o - V \text{ min})$ ohms

Where (R) is the desired resistance, (Ω/V) is the Remote Programming Sensitivity from Section I. (V_o) is the desired output voltage and (V min) is the minimum voltage allowed for the power supply as specified in Section I.

The VOLTAGE ADJUST potentiometers should be set to zero (extreme counter clockwise) when this connection is used.

2.3.5.2 Remote Current Program (where specified in Section I).

R (Ω/I) $(I_O$ - I min) ohms

Where (R) is the desired resistance, (Ω/I) is the Remote Programming Sensitivity from Section I. (I_O) is the desired output current and (I min) is the minimum current.

The CURRENT ADJUST potentiometers should be set to zero (extreme counter clockwise) when this connection is used.

WARNING: DO NOT OPERATE THE POWER SUPPLY WITH EITHER "REMOTE PROGRAM" TERMINAL OPEN CIRCUITED.

2.3.6 Input Connection:

2.3.6.1 For those units supplied without three wire line cord and plug, refer to the applicable Outline Drawing in Table 1-1. Connect the proper wire size specified to the two (2) AC terminals observing that the "high" and "return" leads must be wired to the respective terminals. The system ground is connected to the GRD terminal associated with the AC input terminals.

2.3.6.2 Three-phase Units: All units which are specified in Table 1-1 as "208 volts, three-phase", are intended to be used with a four wire system with the neutral connected. The Outline Drawing indicated in Table 1-1 indicates the correct wire sizes to be used in wiring to the Phase A, Phase B, Phase C and Neutral terminals. In addition, the system ground must be connected to the GRD terminal associated with the AC input terminals. For those units where Table 1-1 specifies input of 460 volts three-phase or 220 volts three-phase three-wire, the system is a three wire system with no neutral. The connection is similar to that of the four wire system except that no neutral load is required.

2.3.7 Constant Current Connection:

Where specified in Section 1, some NJE Power Supplies may be converted to Constant Current Regulated supplies. Figure 2-1 provides information for making this reconnection. Since there are numerous possibilities and parameters which must be considered, the information provided must of necessity be limited. For special applications, consult the factory Application Engineering Department.

On those units equipped with variable current limiting overload protection (See Section 1), and where regulation requirements are restricted, Constant Current applications may be achieved directly without resorting to the more refined connection of Figure 2-1. This method of operation is described in Section 2-5.

2.4 DUALLING:

2.4.1 Cooling of Dual Unit Installation:

Where the dual units are to be rack mounted one directly above the other, the filler panels referred to in Air Flow specification per Paragraph 1.3 must be used. These panels may be ordered from NJE Corporation if the same finish is desired. For standard finish, 1-3/4" by 19" filler panels, order NJE Part No. 22164.

2.4.2 Series Connection:

Those NJE Power Supplies which may be connected in series, as indicated by the Dualling specification in Section 1, can be so connected using Figure 2-2A. If "S" option is required, the unit should be ordered specifying the "S" option. Where field connection is required, reverse voltage protection diodes must be installed to protect against reverse voltage during a short circuit on the series connected supplies.

These diodes should have a Forward Average Current rating equal to or greater than the output current rating of the supply and a Peak Inverse Voltage rating greater than the highest operating voltage of the application. The diodes must be connected in the nonconducting direction across the power supply output terminals. The series connection is quite straight forward and is essentially the same as connecting two batteries in series. Each supply is independently controlled and delivers an output voltage within its own capability. The total output voltage, is of course, the sum of that of the two supplies.

Connection of the series option, including the location of the reverse voltage protection diodes, is clearly shown in Figure 2-2A. The connection of the sensing leads is for the remote sensing mode of operation. If precise regulation at the load is not required, the sensing leads may be left jumpered at the respective output terminals as in Paragraph 2.3.3.

2.4.3 Parallel Connection:

Those NJE Power Supplies which may be connected in parallel, as indicated by the Dualling Specifications in Section 1, can be connected in parallel using Figure 2-2B. The total paralleled current must be derated by 10% from the individual current rating as the two supplies cannot be made to divide the load exactly.

2.5 OPERATION:

2.5.1 The following check list should be followed before making the unit operational:

2.5.1.1 AC power switch in the off position.

2.5.1.2 VOLTAGE ADJUST potentiometer in the extreme counterclockwise position.

2.5.1.3 CURRENT CONTROL$^{\Delta}$ potentiometer (where provided) in the extreme clockwise position.

2.5.1.4 Input wiring made per Paragraph 2.3.6.

$^{\Delta}$Specified as CURRENT ADJUST on some models

2.5.1.5 Output Grounding wired per Paragraph 2.3.1.

2.5.1.6 Output wiring made per Paragraph 2.3.2.

2.5.1.7 Remote Sensing wiring made per Paragraph 2.3.3.

2.5.1.8 Output Capacitor wiring (where provided) made per Paragraph 2.3.4.

2.5.1.9 Remote Programming wiring made per Paragraph 2.3.5.

2.5.1.10 Constant Current wiring (where provided) made per Paragraph 2.3.7.

2.5.1.11 Dualling connection (where desired) made per Paragraph 2.4.

2.5.2 Step-by-step operation based on the location of controls as indicated on the outline drawing specified in Table 1-1:

2.5.2.1 Energize the AC line.

2.5.2.2 Operate the AC power switch to the ON position. The pilot lamp should light.

2.5.2.3 While monitoring both output voltage and current, slowly rotate the VOLTAGE ADJUST potentiometer clockwise until the desired voltage level is reached.

2.5.2.3.1 If the desired voltage and/or current level (within the ratings of the unit) cannot be reached, de-energize the AC line and re-check all connections per Paragraph 2.5.1 above. If still unable to achieve the desired levels, refer to the Troubleshooting Section at the rear of the manual.

2.2.4 CURRENT CONTROL (where provided) may be set to the desired level as follows:

2.5.2.4.1 Method #1: While monitoring the load current, apply a short circuit across the load and rotate the CURRENT CONTROL potentiometer counter-clockwise, until the desired current level is reached.

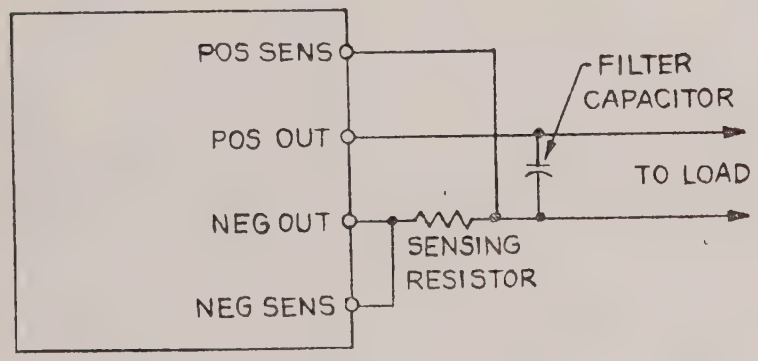
2.5.2.4.2 Method #2: While monitoring the load voltage and current, adjust the load so that the desired levels are reached. Rotate the CURRENT ADJUST potentiometer(s) slowly counterclockwise until the current level begins to fall off.

Where specified in Section 1, some units are provided with MODE lamps. When the above step is performed on these units, the voltage MODE lamp should extinguish and the current MODE lamp should light. A slight clockwise adjustment of the CURRENT CONTROL potentiometer will then set the current limiting just above the operating level. The VOLTAGE MODE lamp should now light and the CURRENT MODE lamp should extinguish.

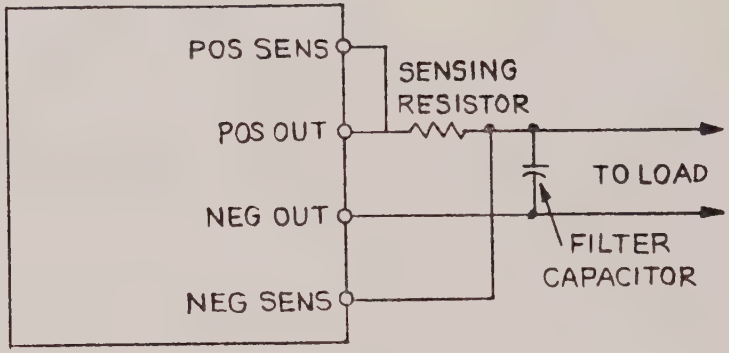
2.5.2.4.3 Method #3: Leaving the CURRENT CONTROL at the extreme clockwise position sets the current limiting action at approximately 110% of the maximum current rating of the supply.

NOTE 1: The current limiting feature is essentially a constant current device. As the load resistance is reduced toward an eventual short circuit condition, the load current will be limited to the present CURRENT CONTROL setting, and it will hold at this value as the output voltage falls toward zero. The current regulation is better than 5% as the load resistance varies to cause a full swing of output voltage and is proportionally better for smaller load resistance changes.

NOTE 2: For the RVC, RB and SVC Lines which are provided with both voltage and current regulation with automatic crossover circuitry, the current limiting characteristic described above is highly regulated. Actual current regulation parameters are in accordance with the specifications noted in Section 1.



ALL UNITS EXCEPT TC LINE



TC LINE ONLY

PROCEDURE

1. SENSING RESISTOR SHOULD BE SELECTED TO PRODUCE APPROXIMATELY 1 VOLT DROP AT MAXIMUM DESIRED CONSTANT CURRENT. RESISTOR WATTAGE SHOULD BE AT LEAST FOUR TIMES MAXIMUM DISSIPATION FOR CURRENT STABILITY. SEE NOTE 4.
2. FILTER CAPACITOR SHOULD BE 6-10 MICROFARADS, OIL OR TANTALYTIC, WITH VOLTAGE RATING GREATER THAN MAXIMUM DESIRED OUTPUT VOLTAGE.

NOTE 1: SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTIONS AND WIRE SIZES.

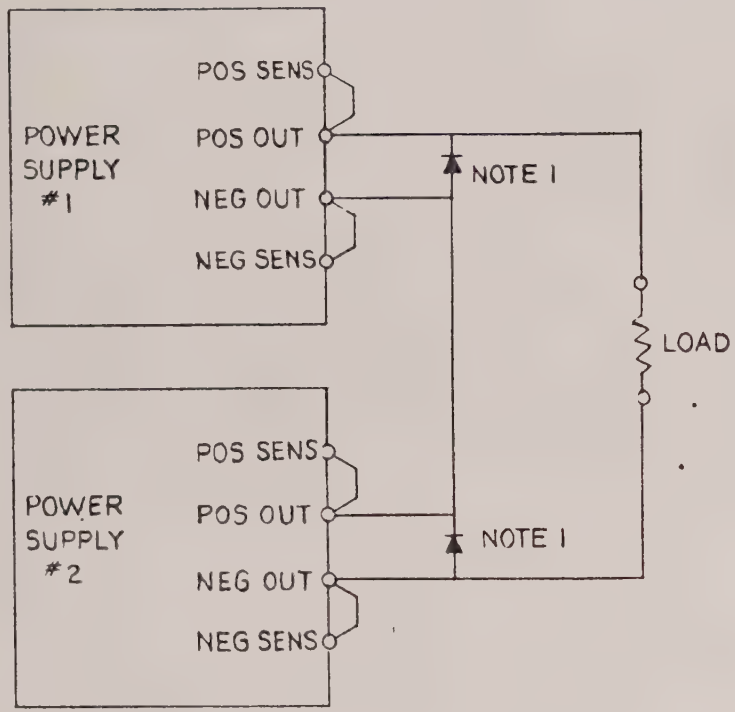
NOTE 2: ON TC UNITS, AN INTERNAL JUMPER BETWEEN TERMINALS 6 AND 11 ON PRINTED CIRCUIT BOARD A2 (96PC) MUST BE ADDED FOR CONSTANT CURRENT OPERATION.

NOTE 3: A POTENTIOMETER APPROXIMATELY 10% OF THE RESISTANCE OF THE OUTPUT ADJUST POTENTIOMETER SHOULD BE INSERTED IN THE PROGRAMMING TERMINALS. THE OUTPUT ADJUST SHOULD BE SET TO ITS MINIMUM POSITION. THE NEW POTENTIOMETER WILL THEN PROVIDE CURRENT CONTROL OVER THE DESIRED RANGE. IF DESIRED, THE OUTPUT ADJUST ITSELF MAY BE USED FOR CURRENT CONTROL, BUT ONLY THE LOWEST PORTION OF THE POTENTIOMETER IS USED. IF AVAILABLE ON THE SUPPLY, THE FINE CONTROL CAN PROVIDE ADEQUATE RESOLUTION.

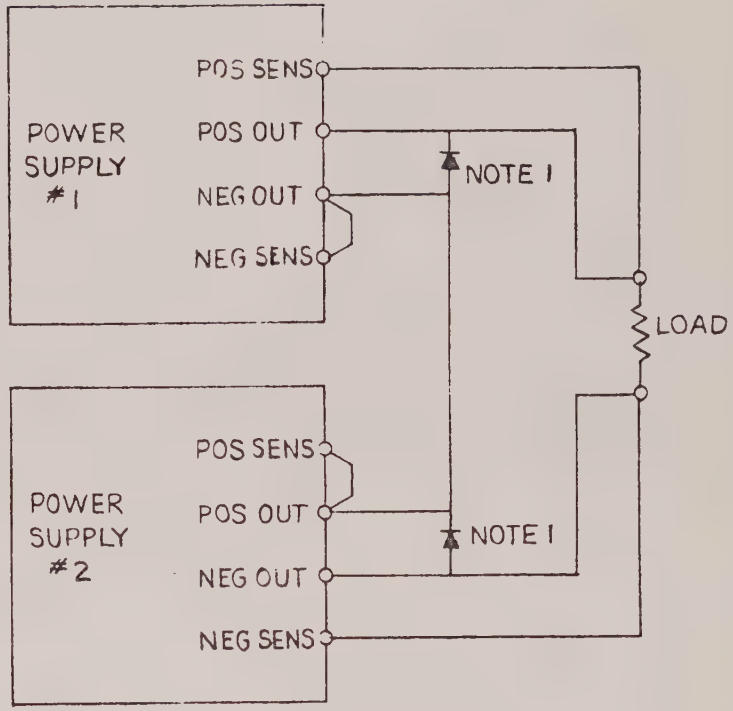
NOTE 4: LOW TEMPERATURE COEFFICIENT RESISTORS WILL IMPROVE STABILITY.

CONSTANT CURRENT CONNECTION

FIG. 2-1



LOCAL SENSING



REMOTE SENSING

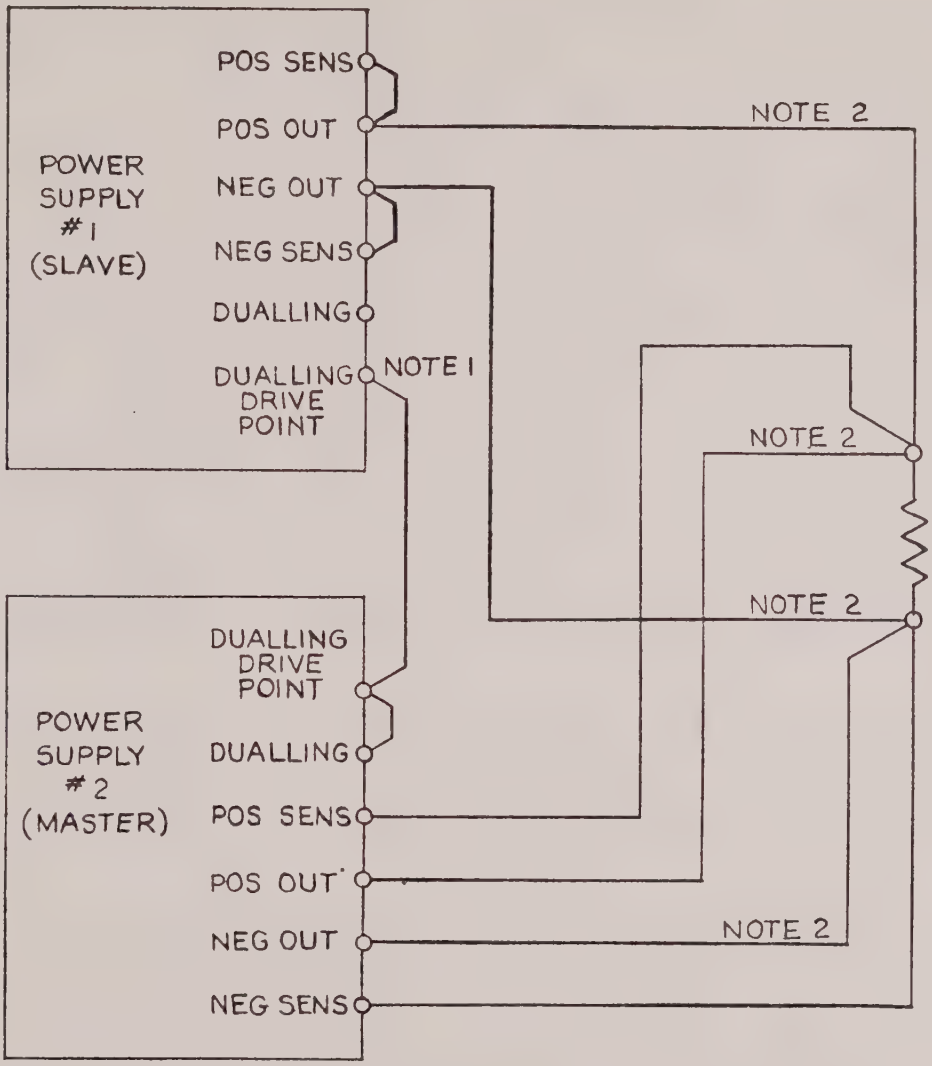
NOTE 1: REVERSE VOLTAGE DIODE, AS REQ'D. SEE PARA. 2.4.2
SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTIONS AND WIRE SIZES.

SERIES CONNECTION

FIG. 2-2A

103949

801578



NOTE 1: JUMPER REMOVED FROM DUALLING TERMINALS ON "SLAVE" UNIT. INTERCONNECT DUALLING DRIVE POINTS BETWEEN "MASTER" AND "SLAVE" UNIT. SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTION AND WIRE SIZES, INCLUDING DRIVE POINT.

NOTE 2: LOAD LINE RESISTANCES SHOULD BE BALANCED CLOSELY FOR OPTIMUM OPERATION.

PARALLEL CONNECTION

FIG. 2-2B

SECTION III

THEORY OF OPERATION

3.1. GENERAL: A simplified block diagram, illustrating the basic elements of the circuit and the signal flow, is shown in Figure 3-1. The AC line voltage is converted to a practical value by the power transformer and after passing through the magnetic storage regulator, is rectified by a full-wave diode rectifier. A capacitor-input filter smooths the pulsating DC output of the rectifier, providing a low-ripple, unregulated DC voltage to the output series regulator. The output voltage furnished to the load by the series regulator is monitored by a feedback amplifier which compares this voltage with a stabilized reference voltage and amplifies the difference between the two voltages. The output of the amplifier is used to control the regulator in such a way that it counteracts any change in the DC output voltage, thereby furnishing an essentially constant voltage to the external load. The magnetic storage regulator is basically a magnetic amplifier which controls the magnitude of average DC voltage at the capacitor input filter in such a way as to maintain the storage voltage across the series regulator within its dissipation capability.

3.2. DETAILED CIRCUIT DESCRIPTION: Circuit references in the following material apply to the schematic diagram at the back of the manual. This diagram shows electrical relationships, without regard to actual physical location of the components, and is laid out in an arrangement approximately the same as that in the Block Diagram, Figure 3-1.

3.3. The power supply is energized by connecting the appropriate line voltage 115 volts (nominal) 60 cycles per second to the input terminals, and closing switch (S1), attested by the lighting of pilot lamp (DS1).

3.4. The power transformer winding (S) converts the input line to an appropriate value on its secondary winding for operation of the magnetic storage regulator (SL1 and SL2). The magnetic storage regulator output voltage is rectified by a full wave rectifier (CR1 and CR2), or (AA) or 160 volt models, providing a pulsating DC output which is smoothed by the capacitor input filter (C1) or (AE and BE) on 160 volt models, and applied through a regulating transistor assembly (A) to the external load. Capacitor (C2) provides additional filtering of the output, and reduces the internal impedance of the supply for high-frequency load variations.

3.5. The output voltage on the auxiliary winding (W), of transformer (T1) is rectified by diodes (CR101 and CR102) and (CR103 and CR104), and filtered by capacitor input filter (C102) and (C103) - (AK) to provide positive and negative operating potentials for the feedback amplifier. Zener diode (CR109) in conjunction with its load resistor (C) provides regulated + 18 volts DC, while diode (CR110) with resistor (D) provides -18 volts DC (measured with respect to the negative output terminal of the unit). These zener diodes function in a manner analogous to that of a gaseous voltage regulator tube, providing a relatively constant output voltage across their terminals despite variations in the conducted current. Output voltage from diodes (CR101) thru (CR104) also provide current for the magnetic storage regulator (SL1 and SL2) control windings, and regulator transistor assembly (A) I_{CO} drain.

3.6. The feedback amplifier consists of three stages of amplification; the first two of which are balanced amplifiers, assuring minimum sensitivity to fluctuations in ambient temperature or operating voltages. The input signal for the amplifier is derived from a voltage sensing divider connected across the output of the supply. This divider consists of resistors (E) and (F) in the amplifier, and resistor (G) (and resistor (C) on model QRP160-3) on the main chassis. The resistance setting of (G) determines the operating value of the DC output voltage of the supply in a manner which will be explained below. Resistor (G) is connected to the output voltage control knob on the front panel. (F101) at the base of (Q108) provides protection for both the precision feedback resistor (G) as well as the transistor differential amplifier during surges arising because of transient load conditions. On QR160-1.2 models, (F101) is not used. Protection is provided instead by diode (CR116).

3.7. The negative end of the sensing voltage divider (negative end of resistor) (F) is returned to the negative output of the supply through zener diode (CR111) and the negative sensing lead. The diode, in conjunction with its load-resistor (H), provides a highly stable potential of 6 VDC for use as a comparison voltage by the input stage (Q107 and Q108) of the feedback amplifier. When the output of the power supply (measured at the load) is precisely at its selected nominal value, the voltage at the base of transistor (Q108) is at the same level as the base of transistor (Q107); and the input stage is in balance. Under this condition, any tendency of the load voltage to vary in either direction will unbalance the amplifier, resulting in corrective action which compensates for the variation and holds the load voltage at its established value, as explained below.

3.8. Transistors (Q107 and Q108) are PNP type units, operated in common-emitter mode, and connected as a balanced differential amplifier. Their outputs, taken across load resistors (I) and (J) are direct-coupled to the bases of the succeeding differential amplifier stage (Q105-Q106) which consists of two NPN transistors operated in common-emitter mode. The output of (Q105), from its load resistor (AD), drives the base of the single ended output stage (Q104). The output of the amplifier at the emitter of (Q104) is tied directly to the base of the driver transistor (Q101).

3.9. Regulation of the DC output is performed by a double regulating system. A transistor series regulator consisting of power transistors (A) operating in parallel provides high speed regulating action to correct for ripple and transient variations both at its input, across C1,(or (AE and BE) on 160 volt models) and at the output of the supply. The amplifier loop which provides correction signals to the series regulator is driven directly from the power supply output through the feedback resistor divider and is comprised of transistors (Q108), (Q107), (Q106), (Q105), (Q104), and driver transistor (Q101). A magnetic amplifier consisting of (SL1) and (SL2) whose control windings are driven by a transistor pair (Q102) and (Q103) is designed to regulate the storage voltage across the series regulator. The circuitry is such that regardless of the output load requirement, the power dissipation of the series transistor regulator is maintained within its ratings.

3.10. The sequence of corrective action for the magnetic storage regulator is as follows: The input to transistor (Q102) is the zero level and is connected to one end of the series regulator, i.e., the negative output terminal. The voltage at the common collector terminals of (A), the other end of the series regulator, is sensed by the three-resistor divider network (M), (Q) and (N) with respect to the +18 volt zener level at cathode (top) end of (CR109). This divider is sensitive to both the voltage across the series regulator as well as the current through it and by feedback amplifier action, tends to null the voltage at (Q103) base with respect to the zero level at (Q102) base. The common emitter of this stage is fed from the positive bias supply at (C102) through resistor (L), or (V) on 160 volt models. The collectors drive the control windings of the magamp, and resistor (U) or (Y) on 160 volt models is a current limiter for the control windings fed from the negative bias voltage at capacitors (AK). The feedback is negative, so that if for some reason the voltage across the series regulator tends to increase (due to an increase in line voltage, for example), a negative-going signal is applied to the base of (Q103), producing a current change in the magnetic amplifier control windings in a direction which tends to restore the series regulator to its original voltage condition. Similar correction occurs for a decreasing series regulator voltage.

Output voltage control is achieved in the following manner. Suppose the Output Adjust (G) is varied to produce a reduced output voltage. Since the series regulator response is much faster than the magnetic storage regulator, a momentary situation develops in which the series regulator voltage increases, i.e., the voltage across (C1) or (BA on 160 volt models, holds momentarily while the output voltage is reduced. As described above, when the series regulator voltage increases, the storage regulator amplifier loop causes the magamp output to restore the original series regulator voltage. In this case, the voltage across (C1) or (BA) on 160 volt models, drops to compensate for the output voltage reduction. It is thus seen that the magamp output across (C1) or (BA) on 160 volt models, tends to "track" the output voltage, and in this manner maintains the series regulator dissipation within fixed limits. Other components associated with the storage regulator are the following:

(R1) or (AB), (and X on QRP160-3 only): A bleeder required to maintain a minimum current in the magamp gates.

Capacitor (C101) and Resistor (AN): Stabilization against oscillations in the magamp feedback loop.

Resistor (BT), or (AP) on 160 volt models: Low impedance bypass for the control windings.

Resistor (R123) and Capacitor (C106), QR160-1.2 only: Stabilization against oscillations in the magamp feedback loop.

3.11 The regulating principle of the series regulator feedback circuit is to maintain balance at the bases of (Q107 and Q108). These bases will maintain balance within a small voltage which is the error voltage due to feedback loop gain level. Due to the high gain of the system, the error voltage will be small, and at maximum, equal to the maximum allowable error of the equipment. The sequence of operation begins by an adjustment of (G) or by any change in current through (G). Either change will unbalance the base of (Q108) with respect to (Q107) base. The system will adjust itself up or down until the voltage levels at both bases are equal. Any load or line change will unbalance the amplifier and require corrective action. One such action will be described. The other disturbances cause the circuit to react in a similar manner. If we wish to raise the output voltage, then the value of (G) is increased. This increase momentarily decreases the voltage at the base of (Q108). The error is amplified through the system and a signal is applied to the base of the series regulator transistor (A) in such a manner as to decrease its storage voltage. The magnetic amplifier at the same time raises the average level across (C1). The rise in the output is such that the voltage at the output terminals divided by the value of (G) is equal to the zener voltage (CR111) divided by (E) and (F).

3.12 The sensitivity and speed of response of the corrective feedback circuit is such that the above-described action occurs almost instantaneously, and the actual excursion of the load voltage is held to a very small value. The circuit is a true proportional regulator, and must allow a small but finite "error" to exist between the required and actual regulated voltage, so that this "error", however small, can generate the correction signal. By proper circuit design, however, the error is held to a value which remains within the specified regulation allowance of the power supply.

3.13 When resistor (G) is readjusted to produce a different value of output voltage, the circuit makes a correction similar to that described above. Altering the resistance in the sensing voltage divider unbalances the input stage of the feedback amplifier, which then causes the circuit to produce a new value of voltage such that the drop across resistors (E-F) again equals the drop across diode (CR111). Reducing the value of resistor (G), for example, momentarily increases the drop across (E-F).

However, this unbalanced condition at the amplifier input causes the DC output voltage to decrease until the drop across (E) and (F) again equals the drop across (CR111); and the circuit stabilizes at this new operating point, establishing a lower value of DC output voltage. See description of corresponding storage regulator action in paragraph 3.10.

3.14. Resistor (F) in the amplifier is provided to permit compensation for manufacturing tolerances in diode (CR111), its load resistor (H) and resistor (E). This resistor (F) is adjusted at the factory (and locked). If any of these components are replaced, check to see that full rated output voltage of the supply is obtainable with the voltage control at maximum clockwise position. If not, readjust (F) to provide full output voltage under these conditions.

3.15. Variable Current Limiting is accomplished by means of circuitry of (A2) and CURRENT CONTROL potentiometer (AF). The overload current limit circuit operates in such a manner as to limit the output current from series regulators (A) to the setting of CURRENT CONTROL (AF). The action of the circuit may be described as follows: (AF) is a voltage divider resistor feeding the base of (Q302). The emitter of (Q302) is connected to the base of (Q101), the main series regulator driver transistor. The voltage level at this point varies with output load current developed across the emitter resistors of the series regulator transistors. Thus, when the load current attains a value high enough to cause the voltage at the emitter of (Q302) to drop below the preset base level, transistor (Q302) begins to conduct. This causes current flow through (R301) which then forces (Q301) to conduct. This action effectively clamps the base drive at (Q104) through diode (CR302). The action is quite sharp once conduction begins. Prior to conduction, the diode (CR302) effectively decouples the overload circuit from the main amplifier. The following discussion is applicable to all models except the 160 Volt models: The circuitry of (Q303), (CR301 and CR303) and (R307 and R308) is provided to protect the series regulators (A) from over dissipation during short circuit when the storage voltage across the series regulators may attain a very high value until the magnetic amplifier is able to decrease the average voltage across (C1). This circuit acts as follows: a voltage divider consisting of resistors (R307) and (R308) is connected between the + 18 VDC, bias point and the collectors of the series regulators (A). The junction of these resistors is connected to the base of (Q303) whose emitter is tied to the negative output terminal of the supply. If the storage voltage across (A) increases beyond a point determined by (R307) and (R308) transistor (Q303) is turned on. This clamps the base of driver transistor (Q101) to the negative output of the unit cutting off its drive current to the series regulators. This action decreases current flow from the series regulator (A) to a very low value until the magnetic amplifier gates decrease the average value of voltage across (C1). This action keeps the dissipation of the series regulators at a safe value at all times. This circuit overrides the current limiting circuitry during short circuit over-load conditions on the output of the power supply, and is designed to protect the series regulators (A).

For the 160 Volt models, a special short circuit "dumping" circuit is provided. This consists of diodes (AS) and (AT), which bypass the short circuit current around the series regulators (A) when the voltage across these latter components rises to a value sufficient to cause the diodes to conduct. At this condition, no additional current flows through the series regulators.

3.2.4 cont'd

With no load on the supply, (A1Q13) is normally conducting thru (A1CR19) and the base of emitter follower (A1Q7) is approximately +0.5 VDC. As the load current is increased so that the drop across the sensing resistor is proportional to that value selected by the CURRENT ADJUST potentiometers (R8A-R8B), the base of (A1Q16) balances that of (A1Q15). The base of (A1Q14) is direct coupled from the collector of (A1Q16) and as (A1Q16) conducts, so does (A1Q14) conduct and decouple diode (A1CR19). This decoupling of (A1CR19) in turn causes (A1Q13) to adjust its current flow since the collector voltage is being driven to the negative voltage of the -12 Volt bias. The negative voltage on the collector of (A1Q13) is direct coupled to the base of the emitter follower (A1Q7), causing (A1Q7) to conduct and (A1CR24) to conduct. Prior to conduction (A1CR24) effectively decouples the current regulating preamplifier from the main amplifier. However, upon conduction (A1CR24) diverts a portion of the current flowing thru voltage divider (A1R59) and (A1R60) thereby causing the voltage amplifier to establish a corrected level of output voltage. The circuitry described is often referred to as "Automatic Cross-Over".

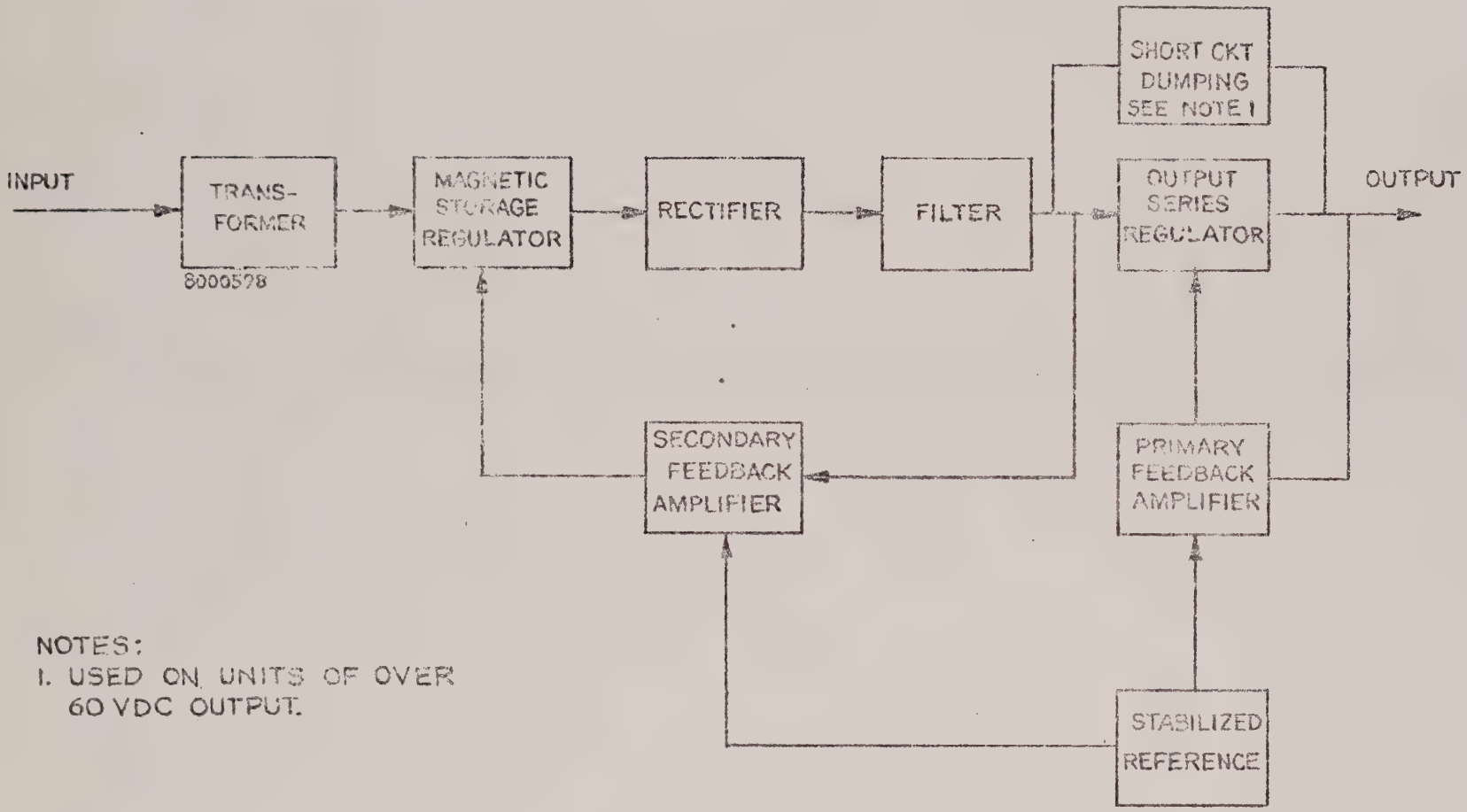
Because of the diverting action of diode (A1CR24), both the voltage amplifier and current amplifier are operating when the supply is in the current mode. Thus, in the region in which load current magnitude is lower than that of the CURRENT ADJUST setting, the diode decouples the current regulator and the power supply is in the voltage regulating mode. In the region in which load current magnitude has achieved a value equal to the CURRENT ADJUST setting, the diode decouples the current regulator and the power supply is in the voltage regulating mode. In the region in which load current magnitude has achieved a value equal to the CURRENT ADJUST setting, the diode conducts and diverts a portion of the feedback current from the voltage amplifier. The power supply is now in the current regulating mode, and the output voltage is adjusted to a lower level depending upon the current diverted by (A1CR24).

3.2.5 TRIGGER AMPLIFIER:

The silicon controlled rectifier trigger circuitry consists of (A1Q1), (A1Q2), (A1Q3), and (A1Q21) and associated components. The circuit adjusts the storage voltage of the pass transistor by controlling the average value of the voltage across (C1). This is accomplished in a manner analogous to thyratron circuitry in which the rectifiers are "fired", and thereby begin conduction, at some point later than the start of the half-wave cycle. Depending on whether the firing point or phase angle of firing is advanced toward the start of the cycle, or retarded away from the start of the cycle, the average voltage across (C1) will be increased or decreased. The circuit is designed to automatically maintain relatively constant voltage across the pass transistor section and at a level at which the total dissipation is limited to a safe value. Thus, the phase angle of firing is automatically adjusted, by means of the circuitry to be described above, to hold the pass transistor storage voltage relatively constant regardless of line voltage or load variations, or of output voltage and/or current adjustments. The trigger circuitry consists of essentially three sections: the charging circuit, the discharging circuit, and the firing circuit. Each is discussed separately.

CAPACITOR CHARGING:

The charging circuitry consists of diodes (A1CR1), (A1CR2), (A1CR5), (A1CR7) and its load resistor (A1R1) and capacitor (A1C6). Diode (A1CR6) decouples the junction of (A1CR1-A1CR2) from the bias voltage output capacitor (A1C4). Thus, the junction point of the three diodes follows the transformer aux. winding rather than remaining at the capacitor potential; and this point effectively moves along the half-sine curve of a typical fullwave configuration. (A1CR5), a zener diode of 12 volts breakdown voltage, establishes that the pulsating DC developed at the junction of (A1CR5) and (A1CR7) is 12 V below that developed at (A1CR1-A1CR2).



NOTES:
1. USED ON UNITS OF OVER 60 VDC OUTPUT.

SIMPLIFIED BLOCK DIAGRAM
FIG. 3-1

REV A - 4-7-64

102533

SECTION IV

MAINTENANCE

4.1 GENERAL: Reference drawings for this power supply are provided in Section V. The exact Schematic Drawing is shown in Figure 5-1. Physical location of components is indicated in the Parts Placement Drawing in Figure 5-2.

This supply is designed for stable operation over long periods of time. However, if trouble develops, standard test equipment normally found in the Electronics Laboratory would be required. If the customer decides to do complete servicing on his premises, one or more of the following pieces of test equipment are required:

Instrument	Range	Remarks
DC Differential Voltmeter	0-500V	Precise Regulation check
Oscilloscope	General Purpose	General troubleshooting
Vaccuum Tube Voltmeter	General Purpose	Ripple measurements
Multimeter (Ohmmeter)		General troubleshooting
AC Voltmeter (precision)	0-150V	Precise regulation check
Variable Autotransformer	Per input rating	General troubleshooting
Dummy Load	Range depends on supply rating	

WARNING!!!

THE POWER SUPPLY SHALL BE DE-ENERGIZED WHENEVER ANY COMPONENTS ARE REPLACED.

4.2.1 PREVENTATIVE MAINTENANCE: The principal item that will require attention is the cooling arrangement. All supplies depend upon convection and conduction cooling for proper operation; and supplies equipped with internal blowers depend upon forced air cooling for proper operation in addition to conduction and convection cooling. Cooling efficiency will be reduced when the supplies are operated in a dust-laden environment, and it is therefore recommended that the supplies be periodically cleaned in order to maintain proper operation.

CAUTION!!

VACUUM CLEANER MAY LOOSEN THE SMALL PLUG-IN TRANSISTORS ! ! ! !

4.2.2 PROCEDURE FOR OILING THE ROTRON MUFFIN FAN: The fan (where provided) may require oil if operated under extreme environmental conditions. The fan incorporates the latest electrical and mechanical advances in the motor design and offers reliable performance for 2 to 5 years under favorable conditions of temperature and vibration without the necessity of oiling. Its life is in inverse proportion to these factors. For example, at 110°F the fan may be expected to give reliable performance in excess of three years and at 40°F reliable performance is extended beyond five years.

If the power supply (equipped with fans) should be installed in areas of greater heat, or severe vibration, the life of the fan may be extended by periodic oiling (a small amount once per year) which is absorbed by the bearing. For this oiling procedure, an OIL INJECTOR, NJE Part No. 021988 is required and may be ordered from NJE Corporation. This OIL INJECTOR will service from 15 to 20 fans. For refills, order Fan Lubricant, NJE Part No. 020923 in 4 oz. cans.

Procedure:

Step 1: Remove cap from end of OIL INJECTOR.

Step 2: Place needle at the center of circle marked on the Gold Label.

Step 3: Position the needle at an angle of approximately 45° to the surface of the label and tangent to the perimeter of the circle.

Step 4: Pierce the label and the concealed self-sealing rubber cap located under the label.

Step 5: Insert the needle approximately 1/4".

Step 6: Depress the plunger of the OIL INJECTOR slowly to the next calibration mark which will allow 1/16" of oil to escape.

NOTE: It is better to give a little more oil than not enough. However, do not overflow the well. If the ambient temperatures are extremely hot, it may be advisable to oil more frequently to insure the optimum performance characteristics of the fan.

4.3 MEASUREMENTS AND TESTS:

4.3.1 Sensing Connection: Sensing lead connections are of utmost importance in making proper regulation measurements. It is recommended that the sensing connections be made directly at the output terminal points rather than at a remote load point. Although the regulation measurement should check correctly at a remote point as well as at the supply terminals, it is well to ascertain that the power supply itself is operating properly without introducing the possibility of extraneous external wiring problems. Thus, all measurements should be made with "local" sensing connections, i.e., with the sensing terminals jumpered directly to the corresponding output terminals. One other point of caution in proper measurement technique is the following:

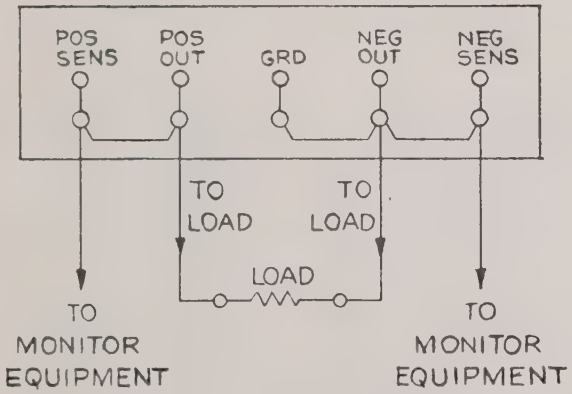
> It is absolutely essential that the measuring equipment connections be made directly to the sensing terminals, whereas the load lead connections must be made directly to the output terminals. Figure 4-1 shows proper and improper connections for measurements taken with "local" and "remote" sensing connections.

Various measurements can be made using essentially the same connections, but using different instrumentation. The following paragraphs describe the basic parameters which may be tested.

4.3.2 Regulation checks: Since regulation of modern power supplies can be as low as 0.001%, special measuring techniques must be employed to accurately check the various regulation parameters. It is necessary to use an external source of DC voltage of approximately the same value as the power supply output as a "bucking" source, connected as shown in Figure 4-2. This DC bucking voltage can be either an electronic, null balance differential voltmeter, or a group of batteries connected in series (or another power supply), furnishing a DC potential slightly larger than the output voltage of the power supply under test. When using a differential voltmeter, the voltmeter is built right into the test equipment. When a "bucking" battery is used, the voltmeter should have a full-scale range low enough to detect the magnitude of regulation expected.

A multi-tester used on the 1 volt range will usually be adequate, since approximately 10 millivolts can be observed reasonably well. The point to note here is that the voltmeter is used to measure only the difference between two almost equal voltages. The balance adjustment (either in the electronic unit, or the test set-up of the diagram) is used to bring the meter needle to approximately midscale before testing, so that the deviation above or below the normal output fo the supply under test can be observed.

CORRECT



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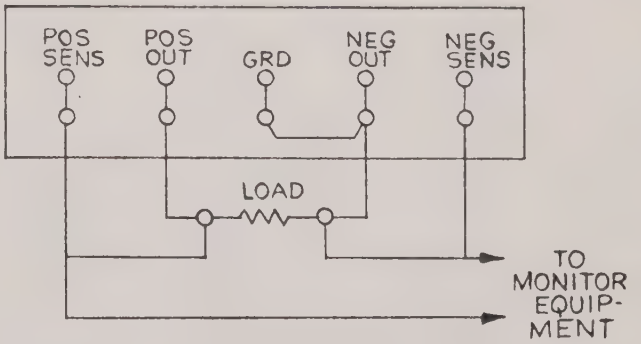

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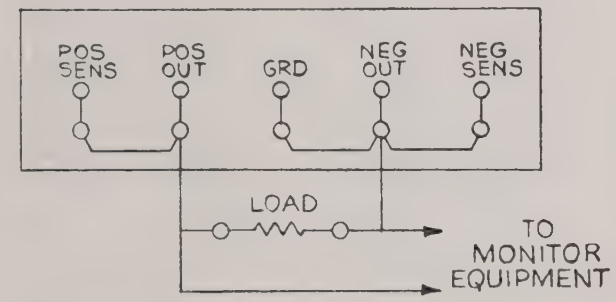

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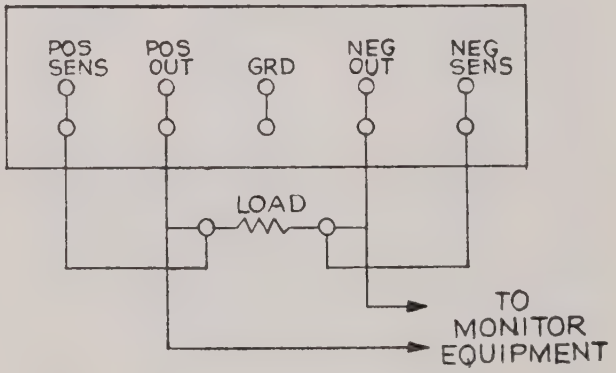


LOCAL SENSING

REMOTE SENSING

MEASUREMENT CONNECTIONS WITH LOCAL SENSING AND REMOTE SENSING

801580

FIG. 4-1

103881

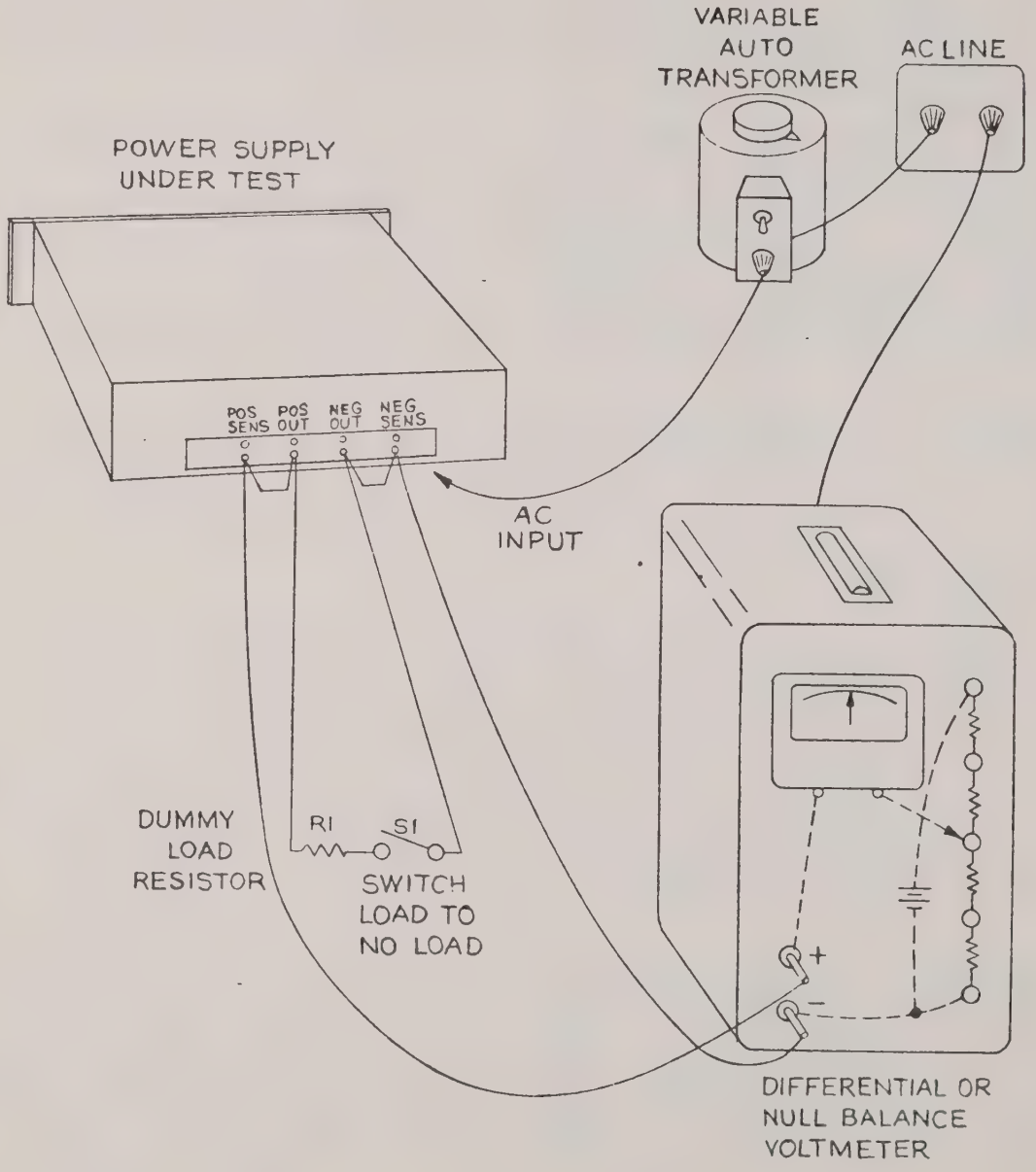
4.3.3 Static Load Regulation: The dummy load (R1) of Figure 4-2 is selected to draw full load current at the nominal output voltage of the supply. The difference between the differential voltmeter readings with the switch open and closed (allowing the needle to come to rest before reading), gives the static load regulation in volts. When load changes are made, it may be necessary to readjust the line voltage to its nominal value.

4.3.4 Static Line Regulation: With the load set at some fixed value, either no load, full load, or some in-between point, the input line is varied by means of the variable auto-transformer shown in Figure 4-2. Note that if this measurement is made under a heavy load condition, the auto-transformer must be selected to supply the necessary input volt-amperes. The difference between the differential voltmeter reading for different line voltage conditions (allowing the needle to come to rest before reading), gives the static line regulation in volts.

4.3.5 Ripple: Either a sensitive VTVM or oscilloscope may be connected directly across the power supply sensing terminals for this measurement. The same set-up is used for the regulation checks may be used if it is desired to observe the ripple under different conditions of the voltage and load current. Be sure to make the measurement connections at the sensing terminals rather than at the load terminals.

4.3.6 Dynamic Regulation and Recovery Time: In the test set-up described above for Static Load or Line Regulation, a calibrated oscilloscope should be substituted for the differential voltmeter. Maximum deflection and recovery time are measured directly, as a dummy load of appropriate value is switched in and out of the circuit. A mercury switch is recommended to minimize arcing, or else an electronic switch should be used. If available, the latter is highly desirable, since the response is readily displayed on the oscilloscope. If the rise and fall time of the current step be at least five times faster than the anticipated recovery time.

4.3.7 Stability: A detailed check for improper drift and intermittent failure can be made by utilizing the same test arrangement as for static regulation measurements. The only requirement is that the differential voltmeter used must have stability of an order of magnitude better than that of the power supply. If available, a stable recorder may be substituted for the differential voltmeter in the drawing, thereby procuring a continuous tracing of the power supply stability.



REGULATION CHECK
TYPICAL LAYOUT

FIG. 4-2

4.4 MALFUNCTIONS: The various ways in which DC power supply can deviate from normal operation are listed below. Each condition is treated separately in the charts that follow. Component symbol designations refer to the schematic diagram at the rear of the manual. Parts locations are indicated in the parts layout drawing also included at the rear.

MALFUNCTION	TYPICAL MAGNITUDE
1. No output voltage at any control setting.	Zero or negative DC output voltage.
2. Low output voltage.	Maximum output voltage obtainable at no load is less than maximum rating.
3. High output voltage.	Minimum output voltage obtainable at no load is more than maximum rating.
4. Failure to regulate.	Output voltage drops 5% or more when load is applied, or varies + 2% or more under a + 10% variation in line voltage.
5. Poor regulation.	Regulation better than above, but not within specification.
6. Excessive ripple.	
A. With good regulation.	RMS ripple exceeds specification, but regulation is within specification.
B. With poor regulation.	RMS ripple exceeds specification, and regulation exceeds specification.

MALFUNCTION	TYPICAL MAGNITUDE
7. Instability.	
A. Random large excursions.	Output voltage "hops" intermittently by 5% or more, with constant load, and constant line voltage.
B. Gradual drift in one direction.	Output voltage changes by 1% or more per minute, after 15-minute warm-up.
C. Excessive drift under heavy load only.	Output voltage changes by 1% or more per minute after a 15-minute warm-up, but only after application of a heavy load.
8. Inadequate transient suppression.	Failure to "zero-lag". Upon sudden application of a full load increase, output voltage dips sufficiently to cause a visible momentary deflection of the voltmeter needle.
9. Oscillation.	
A. High frequency.	Under constant load, output is modulated by sawtooth or sine-wave with frequency of 200 cycles or more per second.
B. Low frequency	At constant load, output voltage exhibits relaxation modulation at or below 200 cycles per second.

4.4.1 No Output Voltage At Any Control Setting

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Pilot light (DS1) not lit.	1. No line power, or defective input connection.	1. Check power source, lines and connections.
	2. Input fuse (F1) blown.	2. Replace fuse. If fuse blows repeatedly, do <u>not</u> overfuse.
B. Repeated blowing of fuse (F1).	1. Shorted rectifiers (CR1 and/or CR2) or (AA), (AS), or (AT) on 160 Volt units.	1. Replace rectifier or rectifiers.
	2. Shorted capacitors (C3 and/or C4), or (AO) on 160 Volt units.	2. Replace capacitor or capacitors.

SYMPTOM	POSSIBLE CAUSE	REMEDY
	3. Shorted rectifiers on (A1) (CR101, CR102, CR103 and CR104).	3. Replace rectifier or rectifiers.
	4. Shorted capacitors C1 or C2 or wiring, or (BE) on 160 Volt units.	4. Replace defective components; clear wiring.
	5. Shorted external overload.	5. Clear overload.
C. Unregulated DC across (C1) zero or low. Fuse (F1) not blown.	1. Open rectifiers (CR1 and/or CR2), or (AA) on 160 Volt units.	1. Replace rectifier or rectifiers.
	2. Open gate windings on (SL1 and/or SL2).	2. Replace (SL1 and/or SL2).
	3. Primary or secondary power transformer (T1) open.	3. Replace transformer (T1).
	4. Magamp circuit controls to zero. This can occur only at heavy loads.	4. Look for cause of load. If it is external, remove, and observe if voltage is affected. When overload condition is corrected and low voltage at (C1) persists, change transistors (Q102 and Q103).
D. Unregulated DC present at (C1).	1. Entire, or major part of unregulated DC voltage across (C1) absorbed by regulator transistors (A). Caused by short or excessive leakage from base of driver or regulator transistors (Q101) or (A), to any positive voltage or ground. For example: If positive output is operated at chassis ground and a wiring short or excessive leakage exists between base of (Q101) and chassis.	1. Inspect for short. Isolate driver transistor from heat sink and chassis, and operate unit for brief interval. If this restores normal operation, replace driver insulation, and/or driver itself, as necessary. If not cleared, repeat for regulators (A).

SYMPTOM	POSSIBLE CAUSE	REMEDY
	2. Amplifier or sensing circuit defective.	2. Check by momentarily shorting base to collector of (Q101). If DC output is restored, amplifier or sensing circuit is at fault. See end of this section for amplifier check.
	3. Rate sensing capacitor (AH), shorted internally, or by external wiring short.	3. Inspect for short. Disconnect one terminal of capacitor. If DC is restored, replace capacitor.
	4. Defective driver transistor (Q101).	4. Check by momentarily shorting base to collector on driver transistor at no load. Replace driver transistor.
	5. Ammeter (M1) open.	5. Check by momentarily shorting meter terminals. Replace.
	6. Resistors (P) all open.	6. Replace defective resistors.
	7. On (A2) shorted (Q303) or open (R307).	7. Replace defective components.

4.4.2 Low Output Voltage Relative To Voltage Adjust Setting.

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Unregulated DC present at (C1), or (AE) on 160 Volt units, in expected magnitude (15 to 30% higher than output voltage at nominal line voltage at no load).	1. Amplifier or sensing circuit defective.	1. Check by momentarily shorting base to collector of (Q101). If this restores DC output, check sensing voltage driver. See end of this section for amplifier check.
	2. Rate sensing capacitor (AH) has excessive leakage.	2. Disconnect one terminal of capacitor. If this restores DC output, replace capacitor.

SYMPTOM	POSSIBLE CAUSE	REMEDY
B. Unregulated DC present at (C1), or (AE) on 160 Volt units, but almost same magnitude as low output voltage.	1. Defective magamp control.	
	a. Magamp sensing defective. Check that base of(Q103) is operated at approximately (within less than 50 mv) of base of (Q102).	a. If bases are equal, check voltage at (CR109) for +18 volts, and check values of resistors (N) (M) (Q) for faulty components.
	b. Faulty transistor (Q102), (Q103).	b. If base to base voltage is unbalanced by more than 50 mv, change the transistors.

4.4.3 High Output Voltage.

A. Output voltage adjust knob has little or no control over DC output.	1. External sensing circuit improperly connected. Internal sensing voltage divider or wiring open.	1. With power off check continuity of sensing leads, internal sensing circuit from positive output terminal to amplifier input and from negative output terminal to neutral bus of amplifier.
B. Output control effective. Driver base (Q101) negative with respect to negative output terminal.	1. a. Bleeder resistors (PN and/or PQ), or (AW) on 160 Volt units, open or regulator transistors (A) I_{co} drain open resistors (AJ).	1. a. Check by applying full load. If this restores normal operation, check for open resistor or connection.
	b. Defective amplifier.	b. See amplifier check at end of this section.
	c. Defective amplifier power supply.	c. Check voltage across filter capacitor (C102 and AK) as shown on schematic diagram. If correct check resistors (L) (C) and (D) for open. If incorrect, check the capacitors (C102, AK), diodes (CR101 through CR104) and secondary winding (W) of transformer (T1).

SYMPTOM	POSSIBLE CAUSE	REMEDY
C. Driver base (Q101) positive with respect to negative output terminal.	1. Defective driver (Q101) and/or pass transistor (A).	1. Check for shorted transistors.

4.4.4 Failure To Regulate

A. Load regulation is 5% or more, line regulation 2% or more.	1. a. Defective amplifier	1. a. See amplifier at end of this section.
	b. Defective amplifier power supply.	b. Check voltage values of filter capacitors (C102 and AK). If incorrect, check the capacitors, diodes (CR101 thru CR104), and main secondary winding of transformer (T1). Check resistors (D) and (C) for open.
	c. Open resistor (R107)	c. Replace if defective.
	d. Very low performance transistor in regulator or driver circuit.	d. Check for equal voltages across resistors in series with emitters of power transistors, to detect defective transistor. Check transistors in a transistor test set or by substitution.
	e. Failure in current limiting adjust circuit.	e. Check transistor first then carefully check other parts for open or shorts and replace any defective components found.

4.4.5 Poor Regulation

A. Load regulation less than 5%, but not within specifications.	1. External sensing circuit incorrectly connected.	1. Check by operating unit with sensing terminals temporarily jumpered to the local output terminals. (Observe correct polarity).
	2. Low gain amplifier.	2. See amplifier check at rear of this section.

SYMPTOM	POSSIBLE CAUSE	REMEDY
	3. Low beta in driver or power transistor.	3. Check by substitution or in transistor tester. Beta of 20 or more is acceptable.
	4. Oscillating amplifier.	4. Check capacitor (AL) proper value. See amplifier check at the rear of this section.

4.4.6 Excessive Ripple

A. Output regulation is within specifications.	1. a. Circuit not bypassed to ground.	1. a. One output terminal of the supply should be connected to chassis ground whenever practical, either directly or thru a 0.1 mfd. capacitor of appropriate voltage rating.
	b. Filter capacitor (C1, C2)-(C102 or AK) open or of low value.	b. Replace defective components.
	c. Note: Ripple at (C1), or (AE) on 160 Volt units, should not exceed 5% of maximum output voltage.	c. Replace (C1) if greater than 5%.
	d. Rate-sensing capacitor (AH) open or of low value.	d. Replace
	e. Hum pickup in external sensing leads.	e. Check by operating unit with sensing terminals temporarily jumpered to local output terminals. Shield external sensing leads.
	f. Low-gain amplifier.	f. See amplifier check at end of this section.
B. Output regulation poor.	1. a. Low beta in power transistor or driver transister.	1. a. Check by substitution or in transistor test set. Beta of 20 or more is acceptable.
	b. Low gain amplifier.	b. See amplifier check at end of this section.

SYMPTOM	POSSIBLE CAUSE	REMEDY
	c. Defective amplifier power supply.	c. Check diodes (CR101 thru CR104) for shorts, or open capacitors, (C102 and/or AK) for open, low value, or high leakage. Check diodes (CR110, CR109) and resistors (C) and (D).
4.4.7 Instability		
A. Random large excursions of output voltage.	1. Intermittent failure of component or intermittent short or open in circuit.	1. Check primary power circuit by temporarily connecting base of driver transistor (Q101) to negative output terminal. If instability persists, check for intermittent breakdown in rectifiers (CR1 and CR2) or (AA) on 160 Volt units, or filter capacitors (C1 and C2). Check for intermittent opens or shorts in unregulated DC circuit. Check driver and power transistors in tester, or by substitution. Check for intermittent opens or shorts, or defective component from (C1) to output terminals. Look for intermittent open or short, or intermittently defective component in (1) amplifier, (2) amplifier power supply, or (3) sensing voltage divider and external sensing circuit. Check amplifier connector for poor contact. Check rate-sensing capacitor (AH). Check voltage across (CR109, CR110 and CR111) for stability.

SYMPTOM	POSSIBLE CAUSE	REMEDY
B. Gradual drift in one direction at any load, after 15-minute warm-up.	1. a. Defective amplifier	1. a. See amplifier check at end of this section.
	b. Drifting zeners.	b. Check (CR109, CR110 and CR111), replace if faulty.
	c. Output adjust potentiometer (G) unstable.	c. Replace if faulty.

4.4.8 Inadequate Transient Response.

NOTE: This condition should be check by oscilloscope at the output terminals of the supply, with the sensing terminals temporarily jumpered to the corresponding output terminals. None of the load current should be permitted to flow through any portion of the oscilloscope leads or the sensing leads.

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Regulation and ripple are within specification, and external sensing circuit is properly and firmly connected.	1. a. By-pass capacitor (C2) open, or very low in value.	1. a. Replace if faulty.
	b. Filter capacitor (C1) low in value.	b. Replace if faulty.
	c. Failure in oscillation damper (AN).	c. Check for defective parts and replace any found in value, open or shorted.

NOTE: A brief transient during switching is normal. The measurement of transient response may be complicated by inductive transients of 1 to 5 microseconds duration due to lead inductance etc., but since these are easily handled by means of local bypassing, they have no significance in determination of the transient response of the supply.

4.4.9 Oscillation

SYMPTOM	POSSIBLE CAUSE	REMEDY
A. Under constant load, output voltage varies at a cyclic rate (sawtooth or sine wave) of 200 cycles or more per second.	1. a. Defective diodes (CR109, CR110) or resistors (C or D).	1. a. Replace if faulty
	b. By-pass capacitor (C2) is open or of low value.	b. Replace if faulty
	c. Rate sensing capacitor (AH) or its circuit is open	c. Replace if faulty
	d. Suppressor capacitor (AL) in amplifier is open or of low value.	d. Replace if faulty
B. Under constant load, output voltage varies in "sawtooth" manner at a frequency of 200 cycles or less.	1. a. Output capacitor (C2) is open	1. a. Replace if faulty
	b. Magnetic storage regulator is oscillating. Check capacitor (C101) and resistor (AN) for proper value. (Check voltage across (C1) or (AK) for sawtooth wave higher than normal 5% ripple.	b. Replace faulty components
	c. Rate sensing capacitor (AH) is open, or of low value.	c. Replace if faulty
	d. Excessive capacitance in external load circuit.	d. If load contains capacitance equal to or greater than output capacitor (C2), special precautions are necessary. Check with NJE Corp. engineering department.
	e. Excessive amplifier gain.	e. If the beta (current gain) of one or more amplifier transistors is 150% or more of the manufacturer's typical value, the increased gain which results (particularly at high ambient temperature) could result in this type of oscillation. Replacement of the transistor is required.

4.5. ALIGNMENT AND ADJUSTMENT: The power supply has four controls that are factory adjusted and normally do not require attention in the field. If any of the components in the error-difference amplifier are replaced, the following readjustment procedure may be necessary.

4.5.1 OUTPUT ADJUST calibration

Step 1: Set OUTPUT ADJUST variable resistor (R5) completely clockwise. The unit may be operated at nominal line and at no load.

Step 2: Place calibrated voltmeter across output.

Step 3: Adjust variable resistor (A1R120) until full rated output is reached.

4.5.2 CURRENT CONTROL calibration

Step 1: Set OUTPUT ADJUST variable resistor (R5) completely clockwise.

NOTE: Verify that the output is the full rated voltage.

Step 2: Set CURRENT CONTROL variable resistor (R8) completely clockwise.

Step 3: Place a calibrated ammeter in series with load.
NOTE: Ammeter of supply may not have sufficient range.
Step 4: Apply a short circuit to Power Supply through external current monitor.

Step 5: Slowly rotate variable resistor (A2 R305) until current level reaches the 110% limit.

4.5.3 Storage Voltage Adjustments (2): Storage voltage is a measure of the voltage across the series regulator transistor (A). It varies only slightly with various line and load conditions on the power supply. It is adjusted by activating the power supply by means of (S1) and then adjusting first the no load storage adjust (Ω) and then the full load storage adjust (M). A preset value of input voltage to the unit and its output voltage adjustment setting for this test follows in a table for all QR type units. "Full Load" means that the supply is loaded by means of a dummy load to its maximum output current capabilities.

4.5.3 (cont'd)

The storage voltage adjustment need never be touched unless (CR109), resistor (N), or transistors (Q102) and (Q103) are replaced. If any or all of these parts are replaced on the unit, then the storage voltage should be checked from the table and readjusted if needed.

STORAGE VOLTAGE TABLE

Model No.	Storage Voltage No Load (adj Q)	Storage Voltage Full Load (adj M)	Input Line Voltage	Unit Output Voltage
QR10-10	8-9 VDC	2.2-3.2VDC	125VAC	10VDC
QR15-20	8-9VDC	2.2-2.5VDC	105VAC	15VDC
QR18-6	8-10VDC	3.5-5VDC	125VAC	18VDC
QR36-4	12-14VDC	6-8VDC	115VAC	25VDC
QR36-10	10-11VDC	2.5-3.5VDC	125VAC	36VDC
QR60-2.5	12-15VDC	8-12VDC	115VAC	40VDC
QR60-6	21-22VDC	11-12VDC	105VAC	60VDC

4.6. FEEDBACK AMPLIFIER CHECK: There are several methods which can be used in checking the performance and condition of the feedback amplifier.

Except for individually removing the transistors for a check by means of a transistor test set, and making continuity and resistance tests on the circuit and components, all methods require the amplifier to be energized with the proper potentials under the conditions found in the power supply for normal operation. For this reason, it is simplest to test the amplifier in position in the supply, first making certain that its DC power supply (transformer T1), rectifiers (diodes CR101 through CR104), capacitors (C102 and AK), diodes (CR109 and CR110) and resistors (C) and (D) are functioning properly. This can be quickly ascertained by checking the circuit voltages as indicated on the schematic diagram. Once this is done, the procedures given below can be used to check out the amplifier itself.

4.6.1 Voltage Check: The simplest and most rapid direct check for the amplifier is made by connecting a temporary jumper from the base of transistor (Q107) to the base of transistor (Q108), thereby balancing the amplifier input stage, and checking for balanced voltages on the two amplifier stage collecters. Any obvious discrepancy will indicate a defective stage, and simple analysis will pinpoint the defective connection or component. Verification is then made by testing the component itself or repairing the connection.

4.6.2 Signal Tracing Check: Since there is an inherent amount of ripple at the input to the amplifier, this ripple signal can be used as a test signal for observing the amplifier performance with the aid of a test oscilloscope. (Ignore any spikes in the waveform. Use only the basic ripple signal when making amplitude calculations). In the event that the ripple is too small for practical use, a small 60-cycle sine wave voltage of convenient amplitude (less than 1/4-volt) can be injected into the amplifier, applying it between the negative output terminal of the supply and (TB1-4) for convenience. Measurement of the ripple at the input to the amplifier, and at the output of each successive amplifier stage will provide an effective check of amplifier performance. The ripple amplitude measured across the bases (or input) of the second stage transistor (Q105 and Q106) should be 20 to 40 times the amplitude at the input to the first stage. The ripple at the base of the next stage, transistor (Q104) should be 15 to 30 times the ripple at the input to the previous stage. The ripple at the output terminal (24) of the amplifier should be roughly the same as the input to transistor (Q104). Radical departure from this set of conditions will point up a defective component or connection, which can then be isolated by inspection and individual test. Be sure not to over drive the amplifier stages as it will cause misleading results.

4.7. STABILITY CHECK: A detailed check for improper drift and intermittent failure can be made by utilizing a test jig similar to that shown for precise regulation check in Figure 4-3. The voltage across the zener diode reference source (CR111) is "bucked out", and monitored by a 0 to 1-volt (or smaller scale, if available) high impedance DC voltmeter (null balance voltmeter). Drift or random instability will be readily visible in this test. Output voltages of the successive amplifier stages and regulating diodes (CR109 and CR110) can then be monitored in the same manner. When checking a given amplifier stage by this method, the output of the previous stage should be shorted to prevent external voltage variations from reaching the stage under test. When installing a new transistor in place of one shown to be defective, the stability check should be repeated, to make certain that the trouble has been eliminated.

QR AND CR UNITS

REVISION: 4/30/68

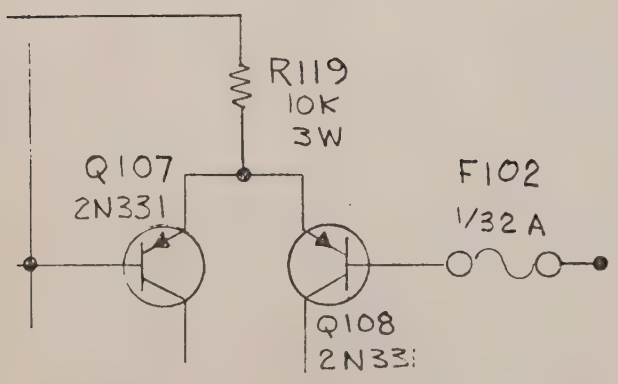
The following changes in circuitry affecting the unit schematic and spare parts lists are effective with the serial no. units listed below. Please note when servicing units or placing orders for spare parts for your specific power supply.

MODEL NUMBER	SERIAL NUMBER OF CHANGE AFFECTED UNITS
CR-18-30	Above 29305
CR-36-15	Above 32991
CR-36-20	Above 31509
CR-36-30	Above 32762
CR-60-9	Above 30103
CR-60-18	Beginning with 29651
QR-15-20	Above 29674
QR-36-10	Above 28058
QR-60-6	Above 29289
QRP-160-3	Above 24741

SCHEMATIC CORRECTION AS BELOW

(ON 67 P.C. PORTION OF SCHEMATIC)

BEFORE



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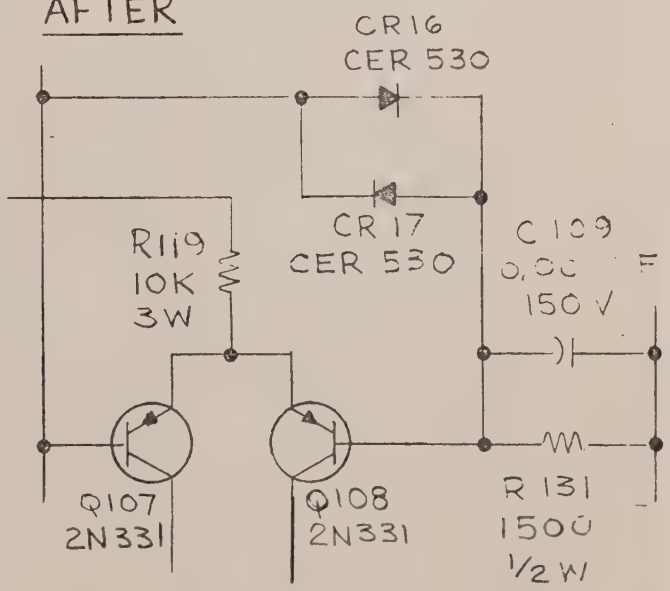
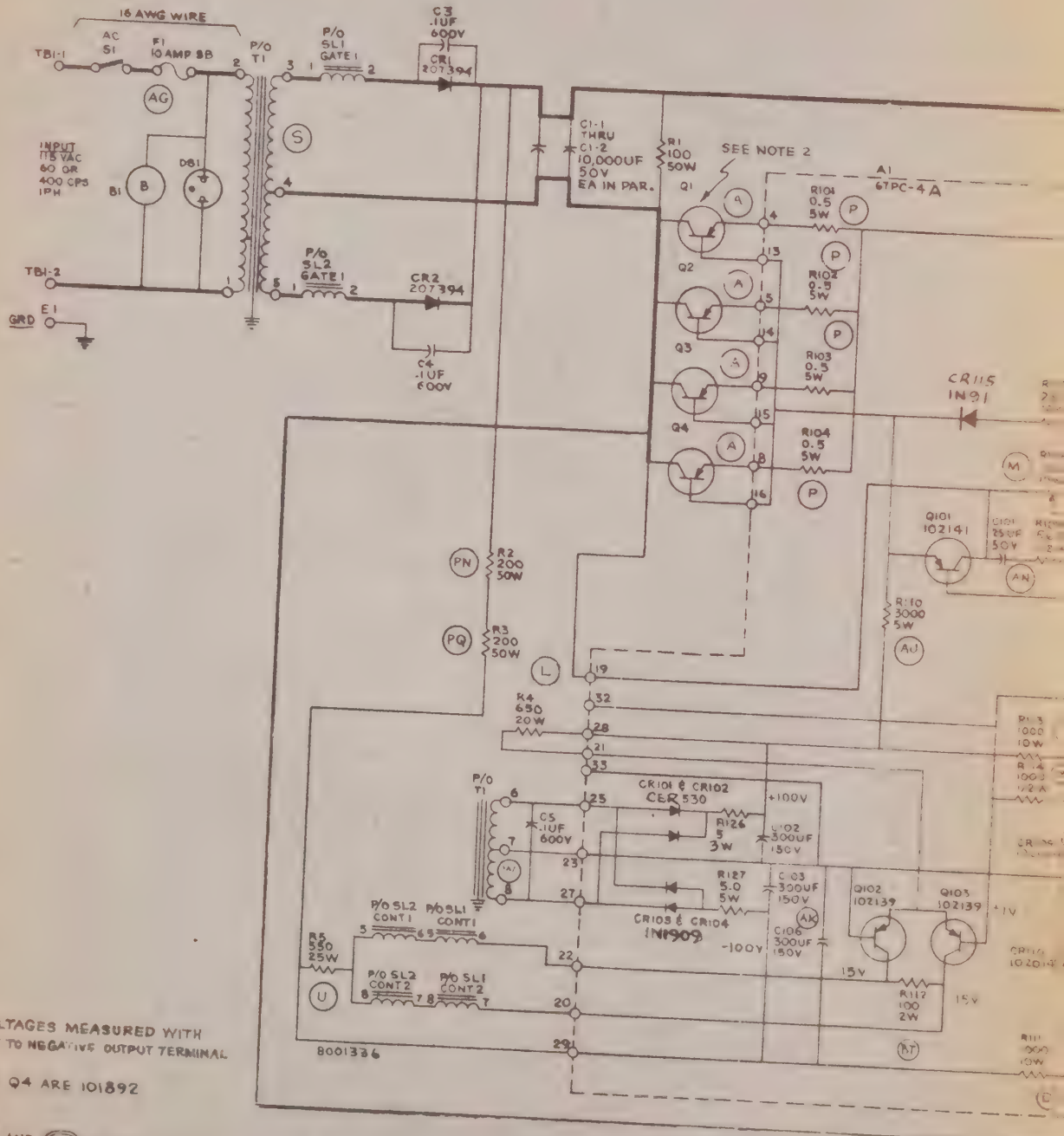


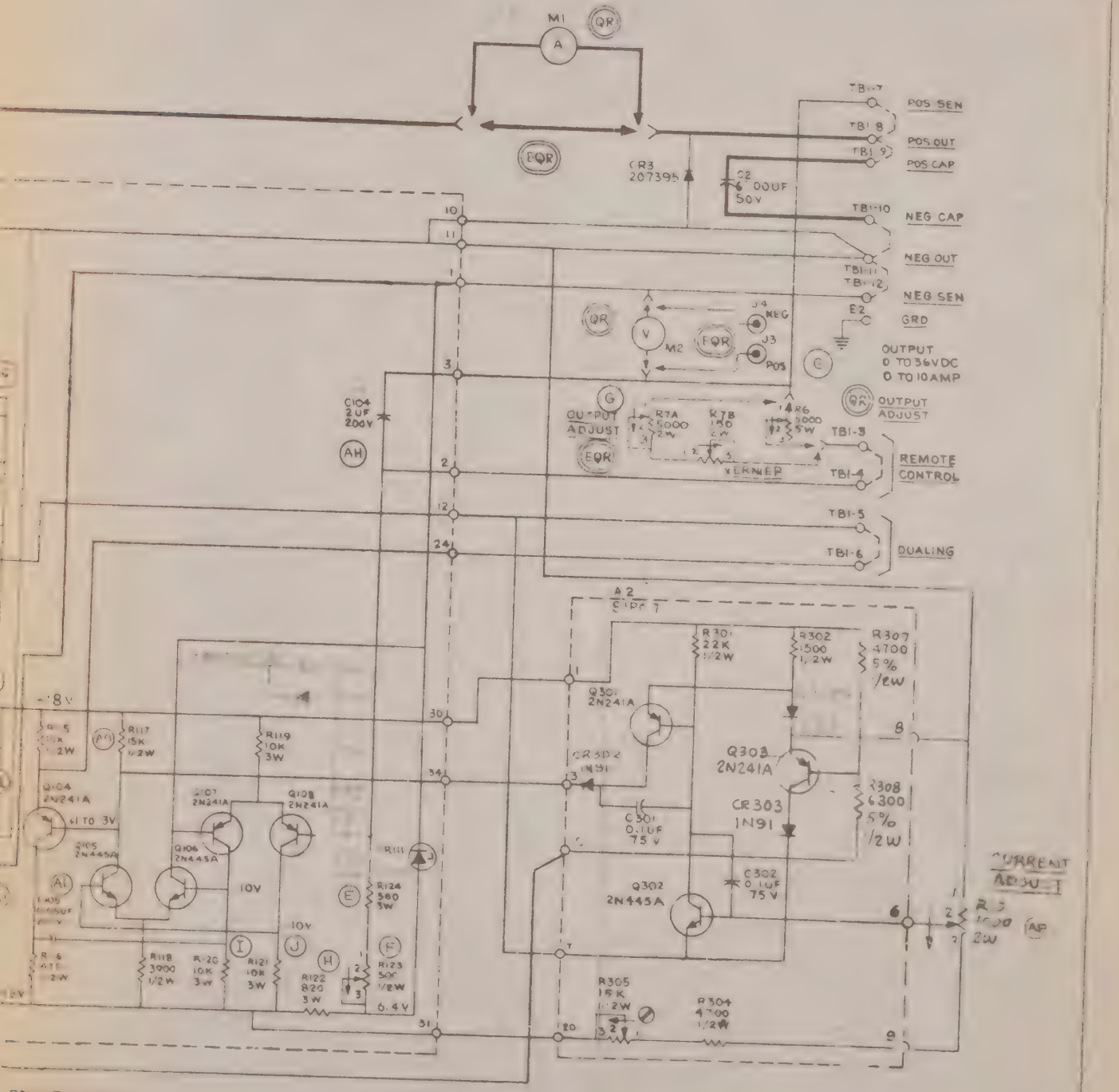


NOTES

1. ALL VOLTAGES MEASURED WITH RESPECT TO NEGATIVE OUTPUT TERMINAL
2. Q1 THRU Q4 ARE 101892
3. THE (QR) AND (EQR) MODELS ARE SIMILAR EXCEPT FOR OUTPUT ADJUST" CONTROLS, MONITORING JACKS AND METERS. OPTIONAL WIRING PROVIDED ACCORDINGLY.

SCHEMATIC FOR D
MODELS QR36 I

REV A ADDED CR3 11-7-63
REV B R116 WAS 5.6, 1W 6/9/66

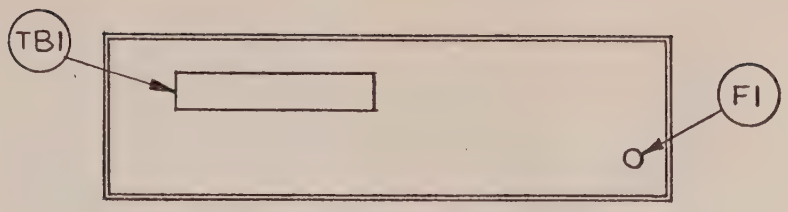


POWER SUPPLY
AND EQR36 10

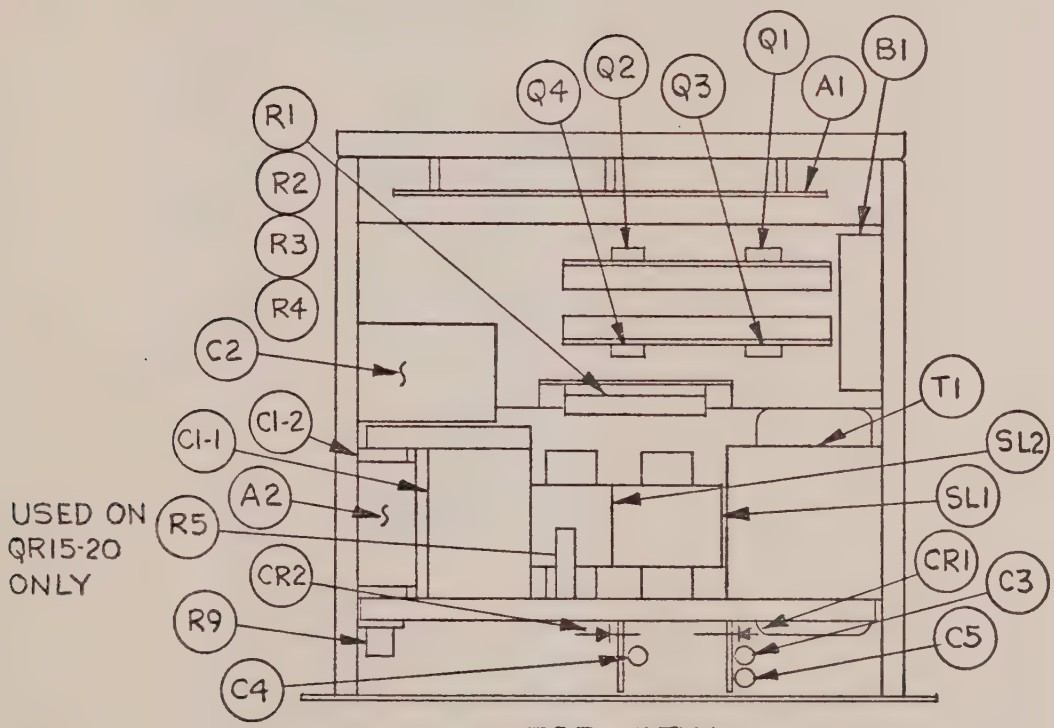
IBM NO. 23467

CENTRAL FILE

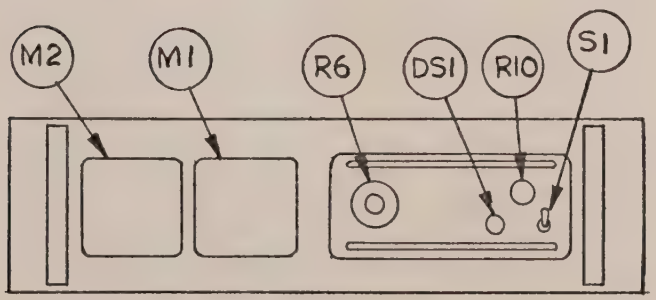
207632
QR & EQR36-10D
SCHEMATIC



REAR VIEW



TOP VIEW



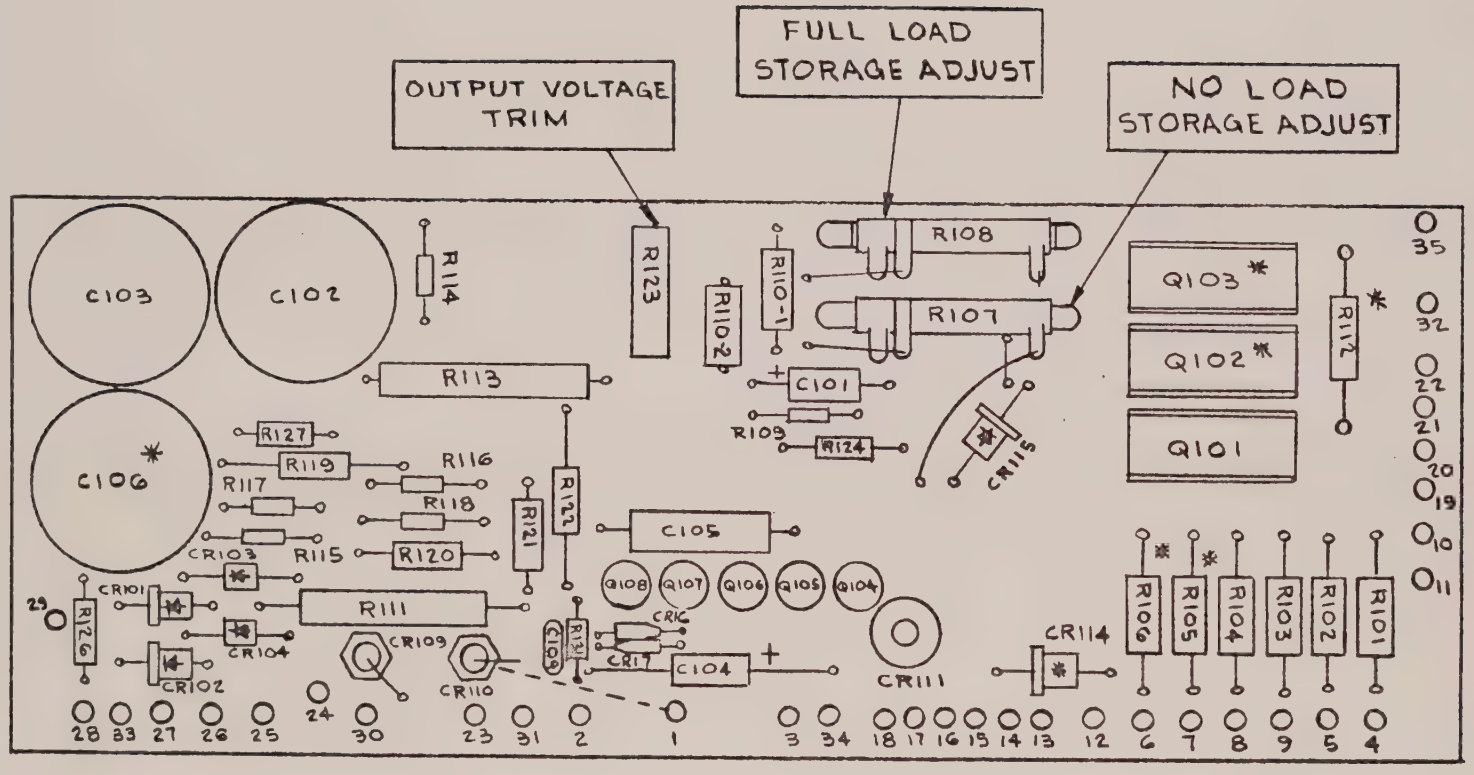
FRONT VIEW

PARTS PLACEMENT - MAJOR COMPONENTS

FIG. 5-2A

800764
REV B 4/5/68

* THESE ITEMS MAY NOT BE USED
REFER TO SCHEMATIC FOR COMPLETE
INFORMATION.



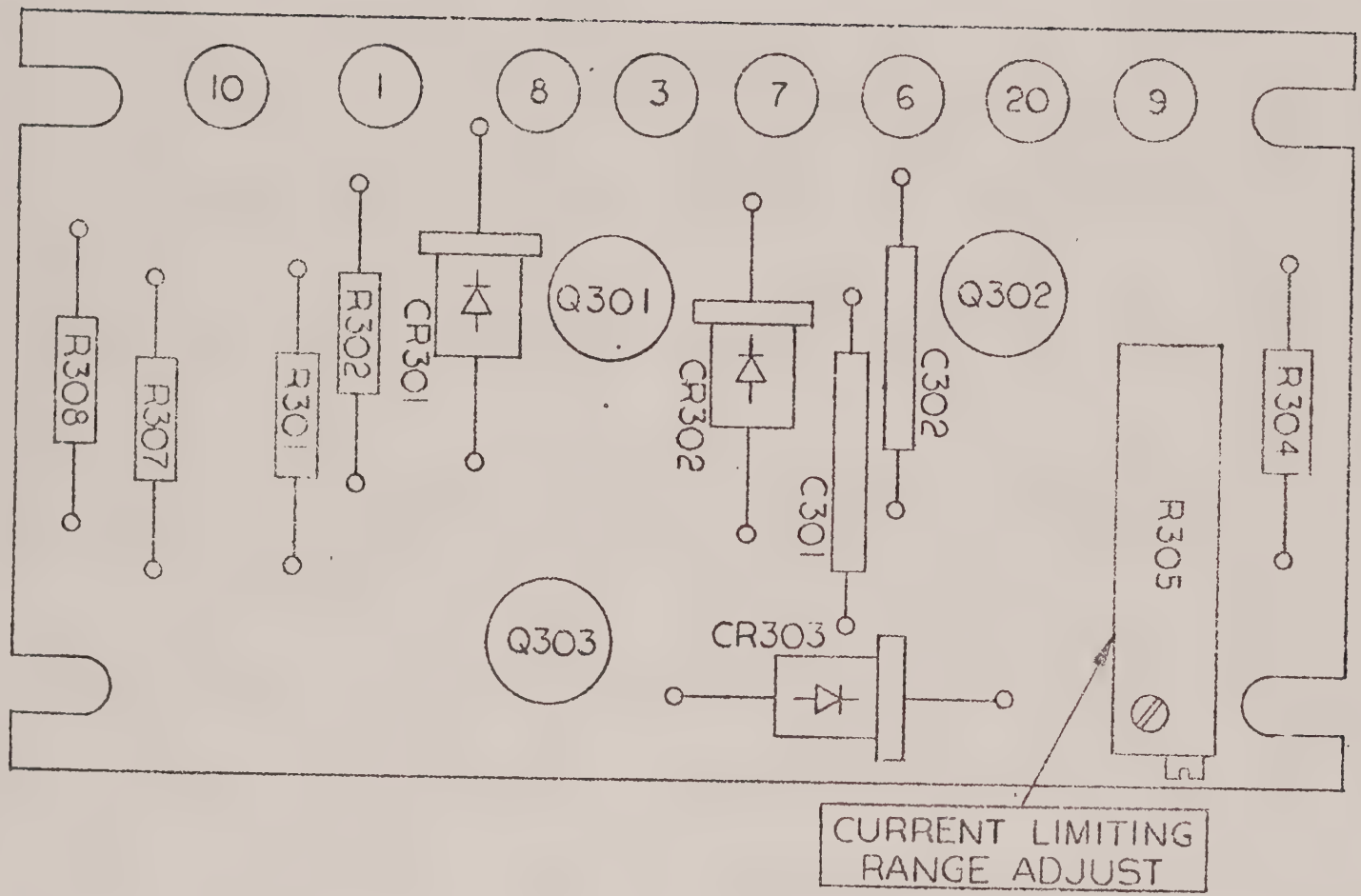
SUBASSEMBLY PARTS PLACEMENT 67PC-
3A, 4A, 5, 5A, 14, 18, 19, 20, 21, 22
FIG. 5-2B

102751

NOT REQUIRED

Fig 5-2C

801711



PARTS PLACEMENT FOR
PRINTED CIRCUIT 'BOARD SUBASSEMBLY(81 PC)

FIG. 5-2D

ABBREVIATIONS USED IN SPARE PARTS LIST

In DESCRIPTION Column: "SA" is used to mean "Same As" and "PO" is used to mean "Part Of". Where these symbols are used, the UNIT QTY., SPARE QTY., UNIT PRICE and NJE PART NO., columns are all blank.

In VALUE Column: The use of the letter "R" to indicate a decimal point is illustrated by the following examples: 5.6Ω is written as 5R60K. 1/2 watts is written as R500 W. The use of zeroes does not imply a precision to the indicated number of decimal places but is a requirement of the proper handling of the Data Processing Cards from which these spare parts lists are written.

The standard symbols for electrical units are used and usually appear in the columns immediately to the left of the dashed and solid lines in the Value field. In all cases, the symbol "Ω" is not printed for resistors and is understood. For example: 200Ω is written 200 and 2.7MΩ is written 2R70M.

In REFERENCE DESIGNATION Column: The reference designations are those which interrelate the Spare Parts List, the Schematic Diagrams and the Parts Placement drawings. The symbols are those of MIL-STD-16. Where the reference designation is an "A" (meaning a sub-assembly), a Spare Parts List bearing the NJE Part Number of that assembly is included in the Spare Parts List section.

Deviations: Where minor deviations are accomplished by modifying a standard unit, a Spare Parts List which only shows the deletions and additions from the enclosed standard Spare Parts List is used.

SPARE PARTS LIST CORRECTION AS BELOW

(ON 67 P.C. ASS'Y. PORTION OF SPARE PARTS LIST)

REFERENCE DESIGNATION	DESCRIPTION VENDOR NAME*	RATINGS VENDOR PART NO.*		NJE PART NO.	QTY. USED	SPARE QTY.	UNIT PRICE
	DELETE						
F101	Fuse Pigtail	0.05 A	125 V	27	1	5	1.90
	ADD						
C109	Cap. Fxd. Cer	0.001μf	150 V	20918	1	1	.60
CR16	Diode Rect. SI.	750 MA	300 V	138	2	1	1.20
CR17	same as CR 16						
R131	Res. Fxd. Comp. 5%	1.50 K	.500 W	1022	1	1	.20

NJE CORP. KENILWORTH, N.J. SPARE PARTS LIST

MODEL PAGE NO. 1-3

REFERENCE DESIGNATION	DESCRIPTION VENDOR NAME*	RATINGS VENDOR PART NO.*		NJE PART NO.	QTY. USED	SPARE QTY.	UNIT PRICE
	QR36 10D			81381			
A1	SUBASSY 67PC 4A			81635	1	1	
A2	SUBASSY 81PC 7			81636	1	1	
B1	BLOWER 60 CPS	115V 1PH	5IN	2	1	1	18.00
C1	CAP FXD ELECT	10000UF	50 V	7	2	1	27.00
C2	CAP FXD ELECT	6700UF	50 V	8	1	1	19.20
C3	CAP FXD PAPER	R1UF	600 V	17	3	1	1.00
C4	SA C3						
C5	SA C3						
CR1	DIODE RECTIFIER S	12 A		20698	2	2	3.00
CR2	SA CR1						
DS1	PILOT LAMP	T3	R250 W	24	1	1	.50
F1	FUSE CARTRIDGE	10R00 A	32 V	30	1	5	.25
M1	AMMETER DC	10R0 A		43	1	1	23.60
M2	VOLTMETER DC	40R0 V		47	1	1	23.60
Q1	TRANSISTOR PNP Su	50 W	55 V	161	4	3	7.00
Q2	SA Q1						
Q3	SA Q1						
Q4	SA Q1						
R1	RES FXD WW	100R00	50 W	89	1	1	2.40
R2	RES FXD WW	200R00	50 W	91	2	1	2.40
R3	SA R2						
R4	RES FXD WW	650R00	20 W	77	1	1	1.20
R5	RES FXD WW	550R00	25 W	84	1	1	1.40
R6	RES VAR WW	5R00 K	10 W	116	1	1	20.00
R7	NOT USED						
R8	NOT USED						
R9	NOT USED						
R10	RES VAR WW	1R00 K	2 W	150	1	1	2.25
S1	SWITCH	SPST	15 A	20605	1	1	1.50
SL1	REACTOR SATURABLE			23315	1	1	40.00
T1	TRANSFORMER			21084	1	1	65.75
TB1	TERMINAL BOARD	12 TERM	20 A	123	1		2.16
XDS1	LAMPHOLDER	RD CLEAR	125 V	20658	1		1.10
XF1	FUSE HOLDER	30 A	250 V	20831	1		.50
	MISCELLANY						
H1	HANDLE	4R652INX1R5IN		2810	1		2.10
H2	KNOB	R250IN	HOLE	21242	1		.65
H3	KNOB DECADE			4563	1		15.00
	FAN OIL			20923			3.00
	FAN OIL INJECTOR			21983			3.50
	67PC 4A SPARE			81635			
C101	CAP FXD TANTALUM	25UF	50 V	21	1	1	7.50
C102	CAP FXD ELECT	300UF	150 V	14	3	1	3.00

*SPARE PARTS LIST SPECIFYING TYPICAL VENDOR'S NAME AND PART NUMBER IS AVAILABLE ON SPECIAL ORDER ONLY.

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is recommended quantity for one year isolated service.

REFERENCE DESIGNATION	DESCRIPTION VENDOR NAME*	RATINGS VENDOR PART NO.*		NJE PART NO.	QTY. USED	SPARE QTY.	UNIT PRICE
C103	SA C102						
C104	CAP FXD PAPER	2UF	200 V	18	1	1	3.75
C105	CAP FXD PAPER	R05UF	200 V	15	1	1	.50
C106	SA C102						
CR101	DIODE RECTIFIER S	750MA	300 V	138	2	1	1.20
CR102	SA CR101						
CR103	DIODE RECTIFIER S	1R5 A	200 V	134	2	2	5.00
CR104	SA CR103						
CR105	NOT USED						
CR106	NOT USED						
CR107	NOT USED						
CR108	NOT USED						
CR109	DIODE BKDOWN 10PC	10 W	18 V	133	2	1	9.50
CR110	SA CR109						
CR111	DIODE BKDOWN 5PCT	250MW	6R2 V	130	1	1	7.00
CR112	NOT USED						
CR113	NOT USED						
CR114	NOT USED						
CR115	DIODE RECTIFIER S	150MA	100 V	129	1	1	1.45
F101	FUSE PIGTAIL	R05 A	125 V	27	1	5	1.90
Q101	TRANSISTOR PNP SI	10 W	55 V	307	1	1	6.00
Q102	TRANSISTOR PNP SI	10 W	40 V	146	2	2	5.00
Q103	SA Q102						
Q104	TRANSISTOR PNP SI	200MW	25 V	139	3	1	2.40
Q105	TRANSISTOR NPN GE	150MW	18 V	142	2	1	2.40
Q106	SA Q105						
Q107	SA Q104						
Q108	SA Q104						
R101	RES FXD WW	R50	5 W	100	4	1	1.20
R102	SA R101						
R103	SA R101						
R104	SA R101						
R105	NOT USED						
R106	NOT USED						
R107	RES ADJ WW	250	10 W	49	1	1	1.60
R108	RES ADJ WW	1000	10 W	52	1	1	1.60
R109	RES FXD COMP	560R00	R500 W	58	1	1	.10
R110	RES FXD WW	3R00 K	5 W	103	1	1	1.20
R111	RES FXD WW	1R00 K	10 W	105	2	1	1.75
R112	RES FXD COMP	100R00	2 W	70	1	1	.20
R113	SA R111						
R114	RES FXD COMP 5PCT	1R00K	R500 W	451	1	1	.20
R115	RES FXD COMP 5PCT	10R00 K	R500 W	475	1	1	.20
R116	RES FXD COMP 5PCT	470R00	R500 W	184	1	1	.20
R117	RES FXD COMP 5PCT	15R00 K	R500 W	530	1	1	.20
R118	RES FXD COMP 5PCT	3R90K	R500 W	464	1	1	.20

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NJE CORP. KENILWORTH, N.J.

SPARE PARTS LIST

MODEL

REFERENCE DESIGNATION	DESCRIPTION VENDOR NAME*	RATINGS VENDOR PART NO.*	NJE PART NO.	QTY. USED	SPARE QTY.	UNIT PRICE
R119	RES FXD WW	10R00 K 3 W	98	3	1	1.20
R120	SA R119					
R121	SA R119					
R122	RES FXD WW	820R00 3 W	95	1	1	.86
R123	RES VAR WW	500R00 R250 W	118	1	1	5.00
R124	RES FXD WW	560R00 3 W	94	1	1	.86
R125	NOT USED					
R126	RES FXD COMP	5R60 1 W	69	1	1	.16
R127	RES FXD WW	5R00 5 W	76	1	1	.90
XQ101	NOT USED					
X102	NOT USED					
X103	NOT USED					
XQ104	SOCKET TRANSISTOR	4PIN	128	5		.70
XQ105	SA XQ104					
XQ106	SA XQ104					
XQ107	SA XQ104					
XQ108	SA XQ104					
	81PC 7 SPARE		81636			
C301	CAP FXD CERAMIC	R1UF 75 V	3	2	1	1.00
C302	SA C301					
CR301	DIODE RECTIFIER S	750MA 300 V	138	1	1	1.20
CR302	DIODE RECTIFIER S	150MA 100 V	129	2	1	1.45
CR303	SA CR302					
Q301	TRANSISTOR PNP SI	200MW 25 V	139	2	1	2.40
Q302	TRANSISTOR NPN GE	150MW 18 V	142	1	1	2.40
Q303	SA Q301					
R301	RES FXD COMP	22R00 KR500 W	68	1	1	.10
R302	RES FXD COMP	1R50 KR500 W	61	1	1	.10
R303	NOT USED					
R304	RES FXD COMP 5PCT	4R70K R500 W	186	2	1	.20
R305	RES VAR WW	15R00 KR250 W	463	1	1	6.25
R306	NOT USED					
R307	SA R304					
R308	RES FXD COMP 5PCT	6R80 KR500 W	529	1	1	.20
XQ301	SOCKET TRANSISTOR	4PIN	128	3		.70
XQ302	SA XQ301					
XQ303	SA XQ301					

*SPARE PARTS LIST SPECIFYING TYPICAL VENDOR'S NAME AND PART NUMBER IS AVAILABLE ON SPECIAL ORDER ONLY.

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